The Welding Engineer

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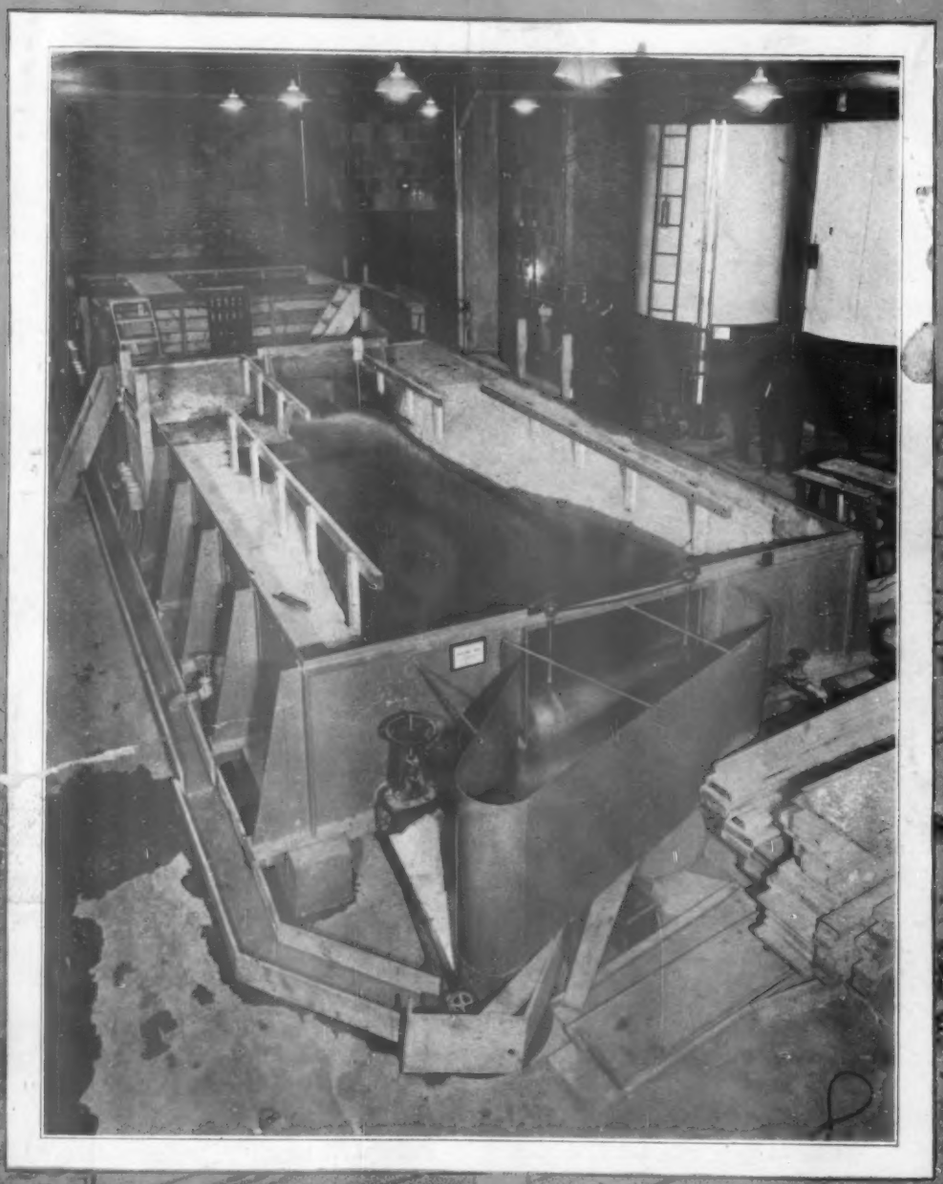

...welded experi-...tal flume being ...d for hydraulic ...ormance. One-...tieth of size of ...al project.

(See Page 24)

...r Business and Technical Journal of the Welding Industry

A LONG STEP. . . .
TOWARD SOUNDER CASTINGS

Control stand, looking toward machine room.

Exterior view — AMSCO X-ray Laboratory.

Exposure room, showing X-ray tube stand—indicating flexibility of apparatus.

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Stereopticon room — filing room

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THE WELDING ENGINEER

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FEBRUARY, 1935

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· E D I T O R I A L ·

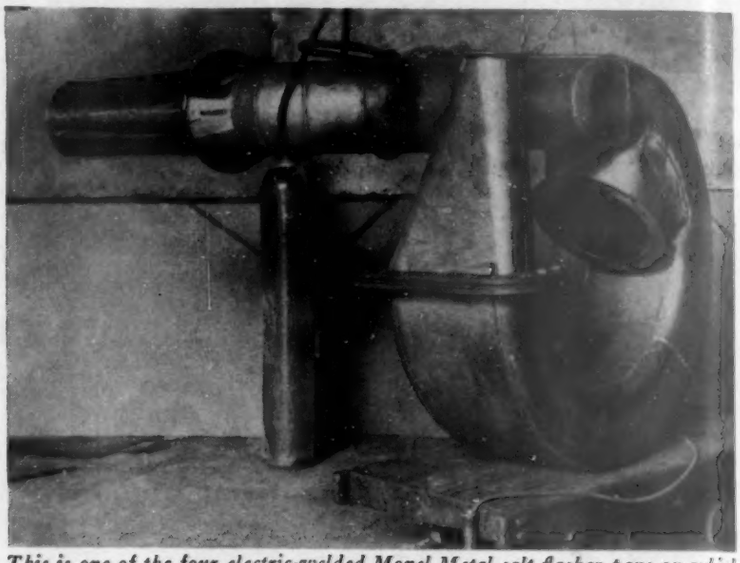
Will Percussive Welding Take a New Lease on Life?

● Some 12 or 14 years ago considerable interest was shown in electro-percussive resistance welding. The electro-percussive method offered a means of reducing the actual welding time to one-tenth of a second or less without a high kilowatt demand from the power system. The method also possessed the advantage of obtaining strong, ductile welds with dissimilar materials. The equipment was somewhat expensive, cumbersome and elaborate, and there was not a demand in those days for heavy shots of power in the welding of metals. For this reason the percussive method of welding was not adopted to any considerable extent. With today's structural alloys, however, the heavy, quick shot of power is being demanded more and more because of the favorable metallurgical conditions obtained in the weld and parent metal. This leads to the question whether the percussive method of welding might not be a solution to some of today's problems in the resistance-welding field. ¶ It is possible to calculate within reasonable bounds the heat required for any given weld. If, for metallurgical or other reasons, it becomes necessary to cut down the time that the welding current is "on," accompanying this decrease in time must be an increase in current, with the result that the maximum kilowatt demand may become excessive, and power costs are increased. If one could store energy during the "off" period and use it to weld during the "on" period, the maximum demand would be cut down. The effect would be much the same as the flywheel on the punch press, which stores up kinetic energy between punches to provide the driving power needed to force the dies together. Without some such energy-storing device, whether it be a flywheel or the motor rotor itself, a very heavy power demand would be made on the supply line and on the driving motor just at the moment of making the stamping. Hence, the flywheel allows a reduction in motor size and a reduced maximum power demand. ¶ In the electro-percussion method of welding, a condenser or an inductive winding constitutes the power reservoir, which fills up before making a weld and overflows at the instant the weld is made. Hence, the energy taken from the supply line is not limited to the small fraction of a second during which the weld is actually made, but is distributed over a longer period—long enough to charge the condenser or to build up the field of the inductive winding. ¶ In considering the possibilities of electro-percussive welding, one must not overlook the fact that the system as it exists at present can be applied only with direct current. If only alternating-current supply is available, it must be transformed to direct current. Moreover, it has been used only for butt welding. In its present state of development, there might be reason to doubt its economies. However, its inherent advantages should provoke one's mind to a realization that here is a system for storing and releasing potential energy that deserves further development with view to applying it to today's welding problems.

The Employment Racket Raises Its Ugly Head

● Certain employment agencies and a few employment managers of metal-fabricating plants have joined forces to foist a scheme upon men seeking work as welders, that amounts to extortion. As the scheme is worked, the applicant is told by the employment manager that he isn't hiring men directly, but he must apply at the So-and-So Employment Agency if he wants a job. When he appears at the agency, he is told that a job is awaiting him, but first he must put cold cash across the line, often amounting to a week's wages or more, and the agency gives no guarantee that the job will last more than a week. The fee paid by the applicant is then split between the agency man and the employment manager of the plant hiring him. To fatten his own pockets, the employment manager won't keep a man on the job any longer than to fulfill legal requirements, which may be only a week, after which the worker is discharged because of "lack of orders" or some other excuse. If he works a week and no more, his entire wage has gone into the pockets of the employment manager and the agency man. Several employment managers, it is reported, have been summarily discharged when their superiors learned of their collusion in the racket. Nevertheless, the racket still continues merrily on. ¶ In every city there are reliable employment agencies to be found, so the man looking for work need not necessarily patronize the unscrupulous agencies. In some cases groups of industries have set up employment offices or bureaus of their own in some central location, where the applicant is examined and reported on, and all applicants are referred to these bureaus before being hired. It is the general practice in such bureaus not to charge the applicant a fee for placement, since the expenses of maintaining the service are borne by the industrial plants benefiting therefrom. ¶ If a welder applies for a job at a plant, and the employment department refers him to a private employment agency, who won't do business with him until they have exacted their fee, he can know that it is nothing less than a racketeering scheme. Then it becomes a question of whether or not to deal with racketeers, which is a matter for his stomach and his conscience to fight out.

AN ADVERTISEMENT FOR NICKEL-BEARING WELDING RODS MANUFACTURED BY THE INTERNATIONAL NICKEL COMPANY



This is one of the four electric-welded Monel Metal salt flasher pans on which Nick worked as described below.

I Cover the WELDING Front

. . . . *and wind up in a schoolroom!*

IT'S A POOR DAY I can't figure on learning something new, like the lad in the story:

You remember *him* . . . his buddy called him a rhinocerous, which he doesn't take any notice to at the time. Then, six weeks later, without any warning he lets go and knocks him cold. The judge asks him how come, and he answers up, "Your Honor, it wasn't until today that I ever *see* a rhinocerous!"

Well it's something like that with me and a salt flasher pan. The Boss gives me a buzz and says, "Nick, go out to Michigan and see how good you are on welding salt flasher pans."

I says to myself, here's another easy job; but I hadn't *seen* one of the pesky things. That's its picture at the top of the page, and it looks like a cross between the insides of an old fashioned hot air furnace and a snail with a belly-ache.

And here's all it has to do when finished: stand a water pressure test of 30 lbs. per square inch, *and* be welded inside in such a way that the entire inner surface can be given a high polish, with *no* porosity or weld metal reinforcement. That's so there won't be even the slightest rough spot that might catch and hold salt crystals.

The fabricator's welding crew were having some trouble occasionally due to insufficient penetration and some cracking, because their orders called for welds from one side only, with no beveling of plate edges.

Well I see at once that we can vee the plates on the inside, and then I go on to weld with ⅛" diameter No. 30 Monel Metallic Arc Welding Rod, using reversed polarity and oscillating the rod slightly across the seam. Then I lay a flat bead from the outside. Not a crack shows up and the inside seams take a polish like a darky's heel. Not a single pinhole or low spot in the whole job. And does she pass her tests with flying colors!

• • •

And now about this schoolroom. It's really called a "clinic" but that sounds too much like a hospital to suit me. It's actually a get-together arranged by Linde Air Products Co. out in Cleveland with a lot of fine, capable welders from all around the Great Lakes, to demonstrate oxy-acetylene welding, brazing and silver soldering. And, of course, Monel Metal, Nickel and Inconel welding was a necessary feature.

One gas welder from a big chemical company comes to the clinic because he faces a job in a few days of welding a Monel Metal coil. We work on some Monel Metal sheets, and after he makes just *two* 6" welds, he starts on 2" Monel Metal tubing and welds *that* . . . without a hitch.

Ten minutes of actual seeing how beats a bookful of printed instructions!

Here's hoping I meet you, too.

Nick Rodder
INCO WELDING SERVICE

INCO WELDING RODS and FLUXES

for **PURE NICKEL**

Oxy-Acetylene . . . "T" Nickel Gas Welding Wire.
Metallic Arc . . . INCO Nickel Metallic Arc Welding Wire No. 31.
Carbon Arc . . . INCO Nickel Carbon Arc Welding Wire No. 21.

for **MONEL METAL**

Oxy-Acetylene . . . Monel Gas Welding Wire. For flux see *below.
Metallic Arc . . . INCO Monel Metal Arc Welding Wire No. 30.
Carbon Arc . . . INCO Monel Carbon Arc Welding Wire No. 20.

for **INCONEL**

Oxy-Acetylene . . . Inconel Gas Welding Wire. For flux see **below.
Metallic Arc . . . Inconel Metallic Arc Welding Wire No. 22.

for **NICKEL-CLAD STEEL**
(for welding of Nickel side)

Oxy-Acetylene . . . "T" Nickel Gas Welding Wire.
Metallic Arc . . . INCO Nickel Metallic Arc Welding Wire No. 31 and No. 35†.
Carbon Arc . . . INCO Nickel Carbon Arc Welding Wire No. 21.

FLUXES

*INCO Gas Welding and Brazing Flux for Monel Metal.
** "Cromalloy" Gas Welding Flux is recommended for Inconel.
† For vertical welding.
No flux is used for the gas welding of Pure Nickel or Nickel-Clad Steel.

INCO welding materials as listed can most conveniently be obtained through regular INCO distributors.
Detailed welding instructions furnished on request.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N. Y.

The Welding Engineer

VOLUME 20 FEBRUARY, 1935 NUMBER 2

Metallurgy of Oxyacetylene Welding of Steel

From a paper read at the 35th Annual Convention, International Acetylene Association, Pittsburgh, Nov. 14-16, 1934.

By J. H. CRITCHETT
Vice-President, Union Carbide and Carbon Research Laboratories, Inc.

OXYACETYLENE welding of steel involves heating the metal from room temperature up to and beyond its melting point; and hence in a metallurgical study of the process it is necessary to consider all the effects—physical, metallurgical and chemical—that can take place in steel over that entire temperature range, both in the solid and liquid conditions. The study, therefore, covers physical changes such as expansion and contraction, metallurgical effects such as crystallization, heat treatment, and the effect of alloys and all the chemical reactions of liquid steel with its surrounding materials. The fact that welding usually progresses along a joint or fracture and that surrounding the point of welding all temperatures are present from normal to that of liquid metal, adds greatly to the difficulty of accurate metallurgical study of the system.

The simplest phenomenon which happens to solid steel on heating is, of course, expansion. This is, in the initial stages and in unrestrained metal, purely a change of volume, and in ordinary steels is a completely reversible change regardless of the rate of heating or cooling. At the same time that it is expanding, the steel becomes increasingly soft, ductile and weak, a fact that has both advantages and disadvantages. Due to this fact, stresses become dissipated and advantageously spread over a wide area because of the ease with which the steel can stretch and yield. Especially is this true in oxyacetylene welding where a considerable area is heated at one time. On the other hand, the low strength at these elevated temperatures makes it necessary to be certain that the piece being welded is free to move so that an undue load is not placed on the hot steel. Particular attention must be paid to the final welds of a closed structure or in joining a light to a heavy section in order to prevent the locking up of stresses in the structure or even, in extreme cases, rupture of the weld metal.

Carbon Precipitates Upon Cooling Below 1400°F.

When plain carbon steel is heated somewhat higher to a temperature called the recalescence point, which depends on the composition of the steel, but lies in the neighborhood of 1400° F., or a bright-red heat, it goes through a metallurgical change of the greatest importance. At this temperature the carbon, which at lower temperatures has existed as discrete particles of iron carbide mixed with pure iron, goes into solution in the iron and at higher temperatures remains in solid solution—a condition analogous to salt dissolved in water. On slowly cooling down through this temperature, the carbon is again precipitated or thrown out as iron carbide. The manner in which the precipitation takes place, and hence the condition of the steel at lower temperatures, is profoundly affected by the rate at which the cooling takes place. When rapidly cooled, the steel is left in a relatively hard and brittle condition, whereas slowly cooled through this temperature, it is soft and ductile.

Another effect which takes place at about the same temperature is recrystallization. When heated much above the recalescence point, steel crystals tend to grow in size to an extent depending on the length of time at the temperature and the amount the temperature exceeds the recalescence point. If, however, the temperature is just above the recalescence point and the time short, the action results in small crystals—a condition which generally means superior physical properties. Another type of recrystallization takes place in steel which is under stress—a condition found in practically all metal that has been rolled in manufacture or formed for fabrication. When stressed steel is heated even below the recalescence point, it recrystallizes in a manner dependent on the amount of stress present. The higher the stress, the lower is the temperature at which recrystallization takes place and the finer the resulting crystals.

Carbon May Be Depleted at High Heats by Presence of Scale

As is well known, steel reacts with the oxygen of the atmosphere at all temperatures. At ordinary temperatures the reaction so commonly recognized in rusting takes place slowly. At higher temperatures the tendency for iron to react with oxygen markedly increases, resulting in an adherent oxide scale which affects greatly the steel just below the surface. At the junction of scale and steel, the carbon of the steel begins, when heated, to react with the oxide of the scale, first at the surface, the carbon being converted to gaseous carbon monoxide, which is eliminated. As the surface of the metal becomes decarburized, more carbon from below the surface migrates through the solid steel to the decarburized surface, carrying on this reaction still further so

that, in the course of a relatively short time, the carbon may be almost completely removed from the steel to an appreciable depth.

When the metal becomes molten, all these reactions can take place at an even faster rate. Iron oxide becomes soluble in the liquid and hence is in a condition to react much more rapidly with carbon and certain other elements contained in the molten steel. At this stage the analogy between the reaction in welding and in an open-hearth steel-making furnace is quite close and it would be helpful, therefore, to consider what does take place in such a furnace.

Reactions in Welding and Open-Hearth Practice Are Analogous

The usual charge for an open-hearth furnace is a mixture of slag-making materials, steel scrap, and pig iron in such proportions that the resultant mixture will have a carbon content of about 1½%. After covering the bottom of the furnace with the slag materials, the steel scrap is charged and then the pig iron on top of the steel. The reasons for the use of pig iron in the charge are partly economic and partly due to the well-known fact that carbon greatly lowers the melting point of iron. By placing the pig iron on top of the charge, it gets the first effect of the heating flame, becomes molten, trickles down over the lower-carbon-steel scrap, and mixes with or fluxes the higher-melting soft steel, thus enabling the charge to be brought to a molten condition much more rapidly than with a charge of soft steel alone.

At the end of the melting period, the slag has risen to the surface and overlies a liquid bath of steel containing slightly less carbon than the mixture charged, but still higher than the carbon content finally desired. A reaction goes on between the carbon in the liquid steel and the iron oxide, derived partly from the rust on the scrap, partly from the flame, and partly from added iron ore. The reaction gives the bath a gentle boil, which is maintained by additions of iron ore until the carbon has been brought down to the desired figure.

The role of one other element—manganese—must also be taken into account here. It is generally accepted in the steel industry that the addition of a small amount of manganese to the initial charge is very beneficial. This manganese becomes oxidized, passes to the slag, is reduced again by the carbon content of the steel bath and redissolved in the steel, and repeats the cycle. However, in going from metallic manganese to oxide in the bath, the oxide combines readily with non-metallic impurities and carries them with it out of the steel bath into the slag. In this way the manganese acts as a very effective cleansing agent on the liquid metal.

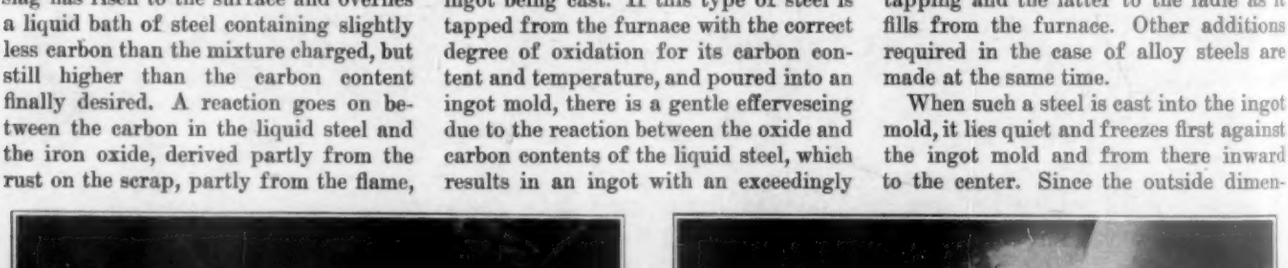
Free Reaction Between Iron Oxide and Carbon Produces Rimmed Steel

Perhaps the simplest product of an open-hearth furnace is so-called rimmed steel, such as would be produced if the furnace were tapped at the end of the operation which has just been very roughly described, except for the addition at the end of a small further amount of manganese. It is, however, simple only in the number of constituents involved. Actually, it is a type of steel that calls for the highest skill of the open-hearth melter. It depends primarily on a definite content of iron oxide for correct behavior in the mold, and the content of oxide varies with carbon content and temperature of the steel and the size of the ingot being cast. If this type of steel is tapped from the furnace with the correct degree of oxidation for its carbon content and temperature, and poured into an ingot mold, there is a gentle effervescing due to the reaction between the oxide and carbon contents of the liquid steel, which results in an ingot with an exceedingly clean and dense surface but filled with cavities or blowholes toward its center. Such a steel is well adapted to the production of many articles which must have a good surface. The strength and other physical properties that this type of steel can have, even when perfectly made, are strictly limited by the fact that only low-carbon steels can be rimmed and the presence of alloying elements is prohibited by the nature of the operation. When this type of steel is imperfectly made, the less said the better, for it is subject to a host of ills and becomes a very low-grade product.

Deoxidized Steel Has Higher Physical Properties

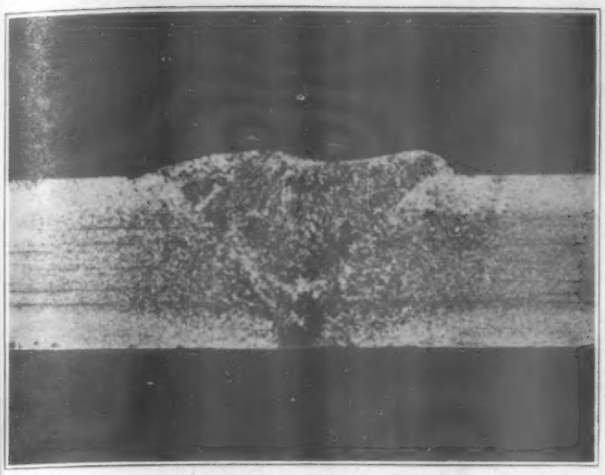
If steel is required having higher physical properties than it is possible to obtain from the rimmed product, the open-hearth process is changed accordingly. The charge is chosen in the same way and the process operates as in the case of rimmed steel to the point where the carbon has been brought down to the desired level. At this time the reaction between iron oxide and carbon is stopped by the addition of 15% ferrosilicon, and spiegel or silico-manganese. The silicon and manganese of these additions reduce all the iron oxide of the steel bath; and when the additions are properly made, the solid products of the reaction (manganese oxide and silica) effectively flux out the last of the impurities in the bath. Additions are then made to bring the steel to the desired analysis. In the case of plain carbon steel, these additions are ferromanganese and ferrosilicon, the first being added to the furnace shortly before tapping and the latter to the ladle as it fills from the furnace. Other additions required in the case of alloy steels are made at the same time.

When such a steel is cast into the ingot mold, it lies quiet and freezes first against the ingot mold and from there inward to the center. Since the outside dimen-



Welding With a Multi-Flame Torch and Carburizing Flame.

(The position of the torch, as shown in the left-hand view, causes the flame to be played backward over the completed weld, thus reducing the rate of cooling, and allowing a partial distribution of strains incident to contraction. The excess-acetylene flame, a close-up view of which is shown at the right, deposits sufficient carbon to be absorbed by the walls of the V in eutectic proportions, whereupon the base metal spontaneously fuses, indicating the moment to apply the welding rod.)



Macrograph of Weld Made With Carburizing Oxyacetylene Flame.

(This welding process allows the use of a smaller V and less welding rod.)

sion of the ingot is established by the mold at the time the steel is poured, and since with such a deoxidized or killed steel there is no gas evolution to form blowholes, the shrinkage in volume during the freezing operation results in a pipe or cavity in the center of the top of the ingot, but the remainder of the ingot is exceedingly dense and solid.

The outline of principles involved has been necessarily cursory and abbreviated but, it is hoped, sufficiently clear for the purposes of this paper. Let us see how they apply to oxyacetylene welding, giving attention first to welding rods and weld metal.

Scale Reacts With Carbon to Cause Porous Welds

The first oxyacetylene welding of good quality was done with low-carbon steel welding rods containing a minimum of other elements. The operation is quite analogous to the making of rimmed steel. In the heating-up of the base metal and the welding rod to the fusion point, both become coated with iron oxide, or scale. Several effects resulting from this fact have a direct bearing on the manipulation during welding and on the quality of the finished weld.

First, the scale on the surface of the metal melts at a lower temperature than the steel itself; hence it must be removed from the surface in order to get adhesion between the added metal and the base metal. The endeavor to be certain that this has been accomplished led to the melting of a considerable amount of base metal, giving a wide weld and excessive consumption of welding gases. Also, in order to make sure that this liquid iron oxide was completely eliminated from the weld, it was necessary to carry the temperature of the metal well above its melting point in order to obtain the liquidity that comes with higher temperatures. Further, the oxide dissolved in the metal reacted to some extent with the carbon, giving rise to blowholes; and the complete absence of silicon, manganese, and other deoxidizing elements prevented a cleaning action such as goes on in an open-hearth furnace during the manufacture of high-grade steel. The carbon content of the rod had to be low to avoid excessive reaction between it and copious amounts of iron oxide that were present, which would have led to a serious number of blowholes in the weld; the scale on the surface of the base metal effectively decarburized it, still further lessening the amount of strength-giving carbon in the weld; and the sluggish-flowing qualities of the substantially pure-iron weld metal led to the ripple type of weld, since the metal had to be blown into place.

In spite of all these difficulties and what now seems like welds having a very low order of strength, these welds served the early days of the industry well. To get good welds in those early days required a high degree of skill on the part of the welder and, therefore, led naturally to the temperamental nature of that worthy gentleman.

Scale-Oxide Reaction Eliminated by New Rods and Procedures

With the growth of the welding industry and increased knowledge of its difficulties and needs, came a realization of the important role played by the rod aside from that of simply supplying metal to fill the scarf or vee. Rods were devised containing the elements on which the steel manufacturer relies for the production of high-grade steel. By the addition of silicon and manganese, the gas-forming reaction between carbon and iron oxide was minimized and replaced by a reaction between iron oxide and these metallic elements. Since the products of the reaction are solid, they do not result in blowholes; and with the proper balance between the silicon and manganese contents in the welding rod, the ratio of silica to manganese oxide is controlled so as to produce a fluid slag which readily floats to the surface of the metal, effectively cleansing the weld metal as it does so and blanketing it against further oxidation.

Eliminating the causes of the carbon-iron-oxide reaction makes it possible to increase the carbon content of this type of rod and consequently of the weld metal to a figure comparable to the usual structural steel. As a consequence, this type of rod yields materially higher-strength as well as sounder welds. The strongly reducing elements in the rod remove the scale on the base metal without leading to further troubles, thereby presenting a clean surface for the weld metal to adhere to, making it unnecessary to melt deeply into the base metal. Further, the increased carbon, silicon and manganese in the weld metal materially lower its melting point so that it flows well and is easily placed where desired. All these factors reduce the strain on the welder and the amount of work that the welding flame must do, leading to better technical results and, equally important, lower costs.

More recently a further advance has been made, this time in the technique of welding which, coupled up with the improved rods, makes modern oxyacetylene welding a very different procedure from that of the early days.

Carburizing Flame Produces Fusion at Lower Temperature

By using a carburizing or excess acetylene flame, the welding blowpipe is made to perform an added function over the usual preheating of the base metal and melting of the rod. The procedure depends on the fact that hot steel readily absorbs carbon, that high-carbon steel has a much lower melting point than low-carbon steel, that carbon very effectively reduces iron oxide, and that carbon disperses or migrates through hot steel at a rapid rate.

The use of the carburizing flame for welding, and directing it backward over the completed weld but in such a way that the flame touches the scarf or vee in advance of the welding puddle, serve first to reduce any iron oxide that may be on the surface of the metal. The reduction of the oxide leaves a very porous, spongy type of iron, which very readily absorbs carbon from the flame, and the melting point falls as the carbon increases until, with fully carburized iron, it is 684° F. below the melting point of carbon-free iron.

This simple procedure thus serves to eliminate the trouble-making gas-producing scale at a point in advance of the welding operation so that blowholes from this source are prevented, and it adds an appreciable amount of strength-giving carbon to the surface of the base metal which, without this treatment, would have been decarburized by its oxide surface.

Moreover, the highly carburized low-melting-point surface of the scarf is easily brought to a sweating condition by advance of the welding operation, with-

out any particular attention being paid to it by the welder. This condition is perfect for forming the union between the liquid metal from the rod and the base metal. There is no need for melting into the scarf to ensure the presence of clean metal for this union, and the welder's attention needs to be directed mainly to the operation of melting the rod. As a result, the width of the groove need not be as great as in earlier methods, hence less rod must be melted to fill it; and this, together with the elimination of melting the scarf, leads to rapid, easy welding at a reduced cost for welding materials.

Needless to say, the highly carburized surface of the scarf is rapidly absorbed by the added metal, and the carbon is diffused uniformly through the weld while still at a higher temperature, giving uniformly strong and ductile weld metal.

Semi-Automatic Welding Makes for Ease and Speed

Another real advantage derived from this type of welding is the ease with which it can be made semi-automatic for certain applications. The reduced attention required from the welder at the focal point of the welding enables construction of an apparatus by which the rod is gravity fed as needed, and employs several flames, each designed to carry out a particular function of the operation. As would be expected, all this leads to an ease and speed of welding impossible under earlier methods.

Constructs Experimental Model by Welding

By J. M. MURPHY

Welded fabrication was used by the Case School of Science, Cleveland, Ohio, in constructing a model in exact detail of the Mohawk Dam, now being built in the Ohio Muskingum Watershed Conservancy District.

Under the direction of Prof. George E. Barnes, head of the Department of Engineering, and Asso. Prof. Jobes, this interesting graphic class demonstration has been carried to completion. It affords the prospective engineer intimate, practical study and application of fabrication and hydraulics.

On a scale of 1-to-40, the all-arc-welded experimental flume tunnels and dam have been constructed in the hydraulic laboratory of the Department of Civil Engineering, all welding having been done by The Thornton Co., of Cleveland. On this miniature model, the student can make detailed tests of hydraulic performances.

While the Mohawk Dam proper will have only a moderate amount of field welding, the gate structures will call for extensive shop arc-welding.

Close-Up View of the Intake.

(To secure the proper arc of spread of the pipe, it was necessary to weld the pipe in short sections. The bolted joint at the throat entrance allows for expansion and adjustment.)

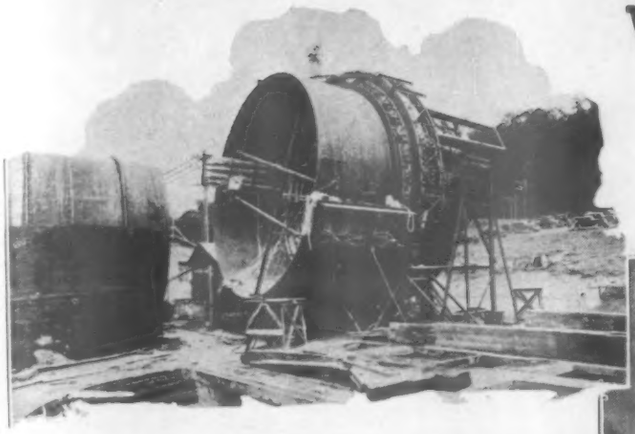
Looking Downstream, With Dam in the Foreground.

Dr. Jacobus to Be Guest of Chicago Section

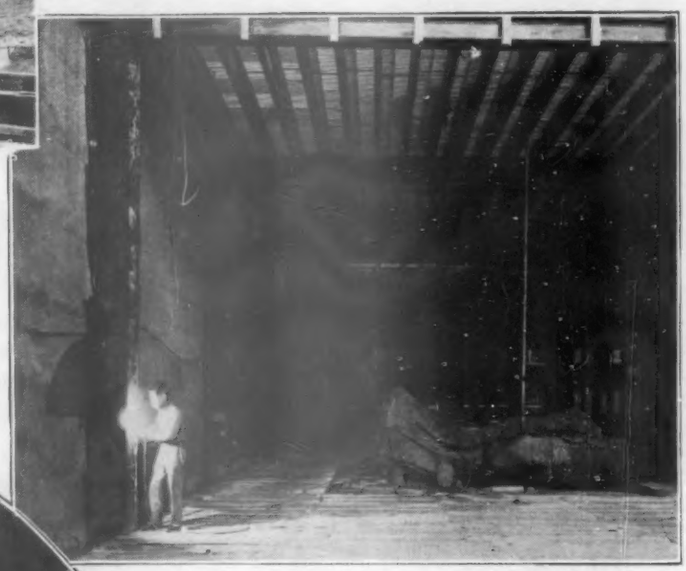
President D. S. Jacobus will be the honored guest of the Chicago Section of the American Welding Society at the regular meeting to be held at 7:30 p. m. on Feb. 22nd. This meeting, which has been arranged jointly with the Chicago Section of the American Society of Mechanical Engineers, of which Dr. Jacobus is a past president, will be held in the auditorium on the second floor of the Engineering Building, at 205 W. Wacker Drive, and will be preceded by a dinner at 6:15 in the Dutch Grill, in the same building. Dr. Jacobus' talk will be on "The Old and the New in Fusion Welding."

At the meeting of the Chicago Section, A. W. S., on Jan. 25th, Thornton F. Bright, consulting engineer, read a paper on "Plate Welding," and a paper on "Alternating Current Welding," prepared by W. C. Pearson, of the Westinghouse Electric & Manufacturing Co., was read by Jules Muller, of the Hollup Corp., in Mr. Pearson's absence.

WELDING NEWS IN PICTURES



• Stress-relieving the longitudinal and girth seams in a penstock section at Norris Dam, Tenn. The section is 20 ft. in diameter and 20 ft. long. Construction by the Chicago Bridge & Iron Works. (Photograph courtesy of The Lincoln Electric Co.)



• Welding strengthening plate to wall column in 9-story addition to the Block Department Store in Indianapolis. A total of 5000 ½-in. fillet welds, each 3 in. long, and spaced 6 in. between welds, were used, requiring 1200 lb. of electrodes. (Photograph courtesy of the General Electric Co.)

• Witches before a boiling cauldron. That's what they resemble, but they are really visitors to the "open house" of the Milwaukee School of Engineering watching a demonstration of vertical welding in the J. D. Adams booth.

• Metal spraying a blower with lead to prevent corrosion. One to three coats are applied. Work being done by Michigan Gases, Inc., Grand Rapids, Mich.

Shrinkage Strains and Stresses Caused by Welding—I

(First of Two Articles)

■ By RIDDERVOLD JENSEN
Naval Architect and Welding Engineer

THOSE who have faced welding problems are acquainted with the fact that localized heating during the welding operation always causes internal stresses or shrinkages or both. The effects may be traced externally either as shortages, if the shrinkages are uniformly distributed over the section, or as warping or indentations caused by irregular distribution.

The successful application of arc welding largely depends upon a thorough knowledge of how these shrinkages take place and stresses arise, in order to control and reduce both of them. Most necessary is this knowledge to the shipbuilder, due to the vast plane areas and large proportions of the hull.

Let us try to explain the character of the shrinkages and the stresses arising when joining two plates with a V-weld, and from our conclusions set out practical rules for the welding.

In Fig. 1 are outlined the various shrinkages and stresses. *A* represents those which act perpendicular to the joint and are evenly distributed over the plate thickness, *B* represents those forces perpendicular to the joint which will try to bend the plate, and *C* shows the forces and effects longitudinally to the joint.

The theory is established of how strains and stresses arise, and ten rules are developed looking to their control and reduction. Though treating specifically of arc welding and ship-building, the principles evolved are in some degree applicable to gas welding and to general welded fabrication.

First, we shall take up the question: Which stresses will arise in the plates in the direction perpendicular to the joint if the plates as shown in *A*(1) are *rigidly fixed*? During welding the groove will be filled with molten material and a narrow zone on both sides will rapidly assume a red heat. The material expands during the heating; and the welding zone, since it is in a very plastic state, will offer slight resistance against deformation. In most cases, therefore, the plates will upset, and only very thin plates will buckle during the expansion. After welding, the heat will spread into the plates, and the cooling through radiation and convection will cause tension stresses. The magnitude of these stresses depends on the amount of heat being added during welding, which again is in direct proportion to the amount of weld metal being applied. Therefore, in order to decrease the stresses it is advisable to comply with the following rules:

1. *Use the smallest amount of weld metal possible.* Make the groove as narrow as possible and still be consistent with good welding. Should the groove become too wide during erection, build it up on one edge at the outset. For very thick plates, as on boilers, use double-V welds, or U-shaped grooves instead of V-shaped.

2. *Preferably use electrodes which yield the least heat per unit of weld deposit.*

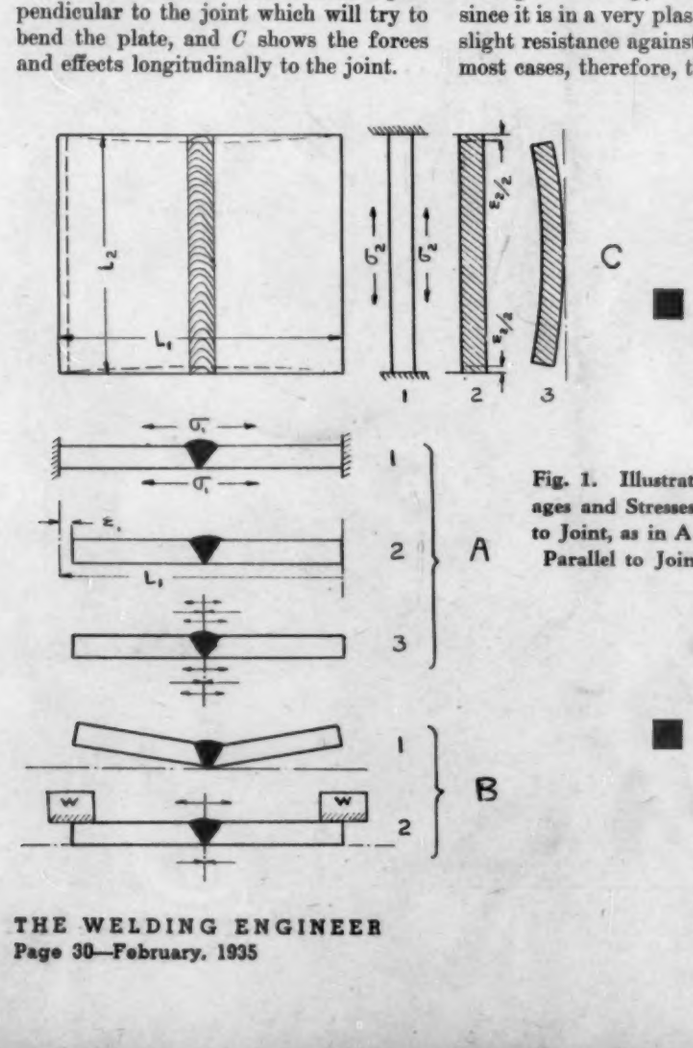


Fig. 1. Illustrating Shrinkages and Stresses Transverse to Joint, as in A and B, and Parallel to Joint, as in C.

At Just Below 70°C., Shrinkage Is Large and Steel Cools Slowly

The *amount of shrinkage* during cooling depends on the linear coefficient of expansion of the steel, and the *speed of shrinkage* depends on the specific heat and the thermal conductivity of the steel at the various temperatures. Fig. 2 illustrates these values for ordinary carbon steel. The curve of the linear coefficient of expansion between 700° and 900° C. has an irregular course on account of the allotropic modifications of the steel at these temperatures. At a little under 750° C., it is noted, the linear coefficient of expansion is particularly large, and then decreases with the temperature. The shrinkages therefore are rather intense at temperatures just below about 750° C.

The greater the value of the specific heat of the steel, the more heat will the steel be able to hold at a certain temperature and the slower will the cooling take place, if we assume that the same condition of loss of heat prevails. As shown by the curve of the specific heat of the steel, a maximum value occurs at temperatures just below about 750° C. Therefore, at this temperature the steel has a tendency to cool rather slowly.

As regards the thermal conductivity, we note a gradual decrease with increasing temperatures.

To judge the magnitude of the stresses

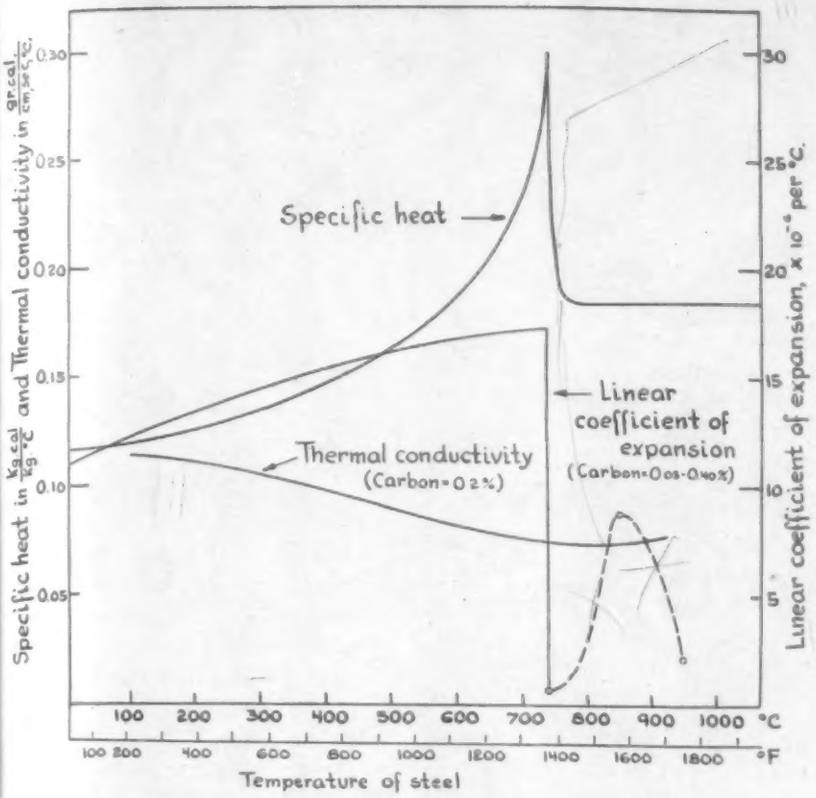

Specific heat
Linear coefficient of expansion (Carbon-0.05-0.10%)
Thermal conductivity (Carbon-0.2%)
Specific heat in kg.cal/kg °C and Thermal conductivity in gr.cal/cm sec °C
Linear coefficient of expansion, x 10⁻⁶ per °C
Temperature of steel
°C
°F

Fig. 2. Linear Coefficient of Expansion, Specific Heat, and Thermal Conductivity of Mild Steel, at Various Temperatures.

caused by cooling, one must know the strength properties of the steel at various temperatures. Fig. 3 shows the values of these properties for a steel of boiler-plate quality with the same tensile strength as shipbuilding-quality steel. We note that the tensile strength σ_B has a maximum value between 200° and 300° C. and that the elongation δ and the reduction in area Ψ have minimum values in the same range of temperatures, which is usually called the blue-brittleness range. The tensile strength and the yield point decrease rapidly at higher temperatures, and at 600° to 700° C. the numerical value of the yield point is very small.

Final Stress Depends on Rapidity of Cooling

Keeping in mind our instance of rigidly fixed plates, we conclude that no stresses of any magnitude will arise during the cooling until the temperature of the welding zone has decreased to about 700° C. If the loss of heat to the air does occur *slowly*, the heat will have time to spread into the plate. The shrinkage will then take place mostly at lower temperatures corresponding to higher values of the yield point. The final tensile stress in the fixed plate would then correspond to the shrinkage of the steel material from a welding-zone temperature of about 700° C. to the temperature of the air, or perhaps more concisely expressed: The tensile stress will correspond to the shrinkage due to the loss of heat occurring from the moment when the welding zone has a temperature of about 700° C. and up to the time that the whole plate has been cooled to the temperature of the air.

If the loss of heat occurs *rapidly*, and therefore at higher temperatures, the stresses due to shrinkage may easily exceed the small value of the yield point at these high temperatures. The steel will take on a permanent deformation during this plastic state, and the tensile stress in the fixed plates will be less and will correspond perhaps only to the shrinkage of the steel from a welding-zone temperature of, for instance, 500° C.

The requirements for such a speedy cooling in the red-heat range are best fulfilled when the heat is being added rapidly; that is, when putting the same amount of weld metal in place in a shorter time. The heat will then have less time to work its way into the plate, and we get a narrow zone with relatively high temperatures instead of a broad band with lower temperatures. In the first instance, the cooling will take place most quickly, because the loss of heat through radiation is proportional to the absolute temperature raised to the 4th power. By welding rapidly, a greater part of the heat will be radiated, as the steel is still plastic. We then formulate the rule:

3. *Preferably use methods or electrodes which produce a greater amount of weld metal in a unit of time and so promote rapid welding*, as far as this may be consistent with good welding practice. This may be attained by: (a) using as great a welding current as possible, (b) using as big an electrode diameter as possible, or (3) selecting an electrode with a great speed of melting (and small sputter losses).

As mentioned, the welding stresses in plates with fixed ends depend upon the amount of heat in the plates at the moment the welding zone is cooled to 500°-700° C. (a dark-red heat). The writer has used this fact as a basis for estimating the stresses from calorimetric measurements. The amount of heat in the test piece was measured just after the welding of a prefixed amount of weld metal in a prefixed length of joint on 10-mm.-thick plates. The test arrangement, which was not worked out for any great accuracy, will not be described, but the results were as follows:

Shrinkage Stresses Calculated From Total Heat Input

Using the data given above, we can estimate the size of the shrinkage stresses in a direction perpendicular to the seam when the ends of the plates are fixed. Assume plates 10 mm. thick and 1 m. wide, with a distance between the fixed ends of L_1=2 m. The plates are joined by a single-V weld with bare electrodes. We can assume that 890 grams of weld

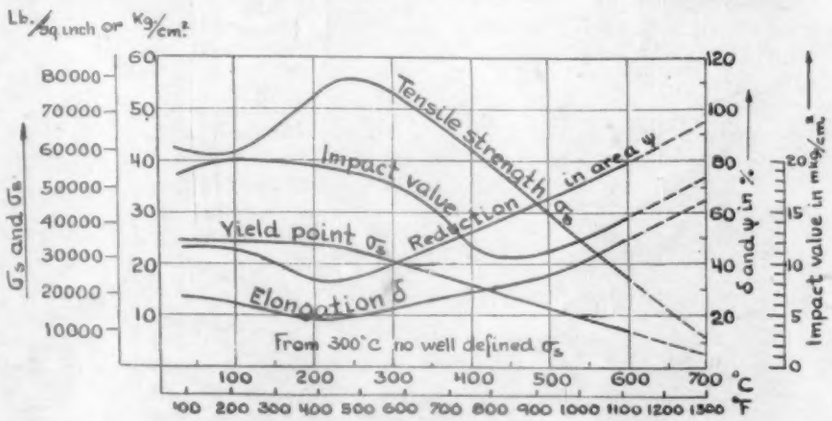


Fig. 3. Strength Properties of Steel at Various Temperatures.
Steel: 41-50 kg./mm.², C, 0.11; Mn, 0.52; Si, 0.17; P, 0.031; S, 0.047.
Ref.: G. Urbanzyk, in *Stahl und Eisen*, No. 27, 1927.

Amount of Heat per Gram of Weld Metal for 3 Kinds of Electrodes

Kind of electrodes	Pole	Volts	Amp.	Rate of depositing weld metal (grams/amp./min.)	Amount of heat in the plate at a welding-zone temp. of 500 to 700 C. (cal./gram of weld metal)
Bare, 4-mm. diameter for structural work	—	17.5	140	0.1415	1.31
Covered, 4-mm. dia. coating, 0.45 mm. thick	+	18.0	140	0.1400	1.38
Covered, 4-mm. dia. coating, 0.90 mm. t i:k	+	27.0	140	0.1555	2.09

metal is applied per meter length of joint. The weight of the plates is 156 kg. From the data given in the foregoing

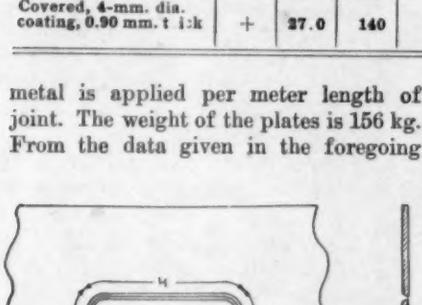


Fig. 4(a). Method of Welding a Patch in a Plate.

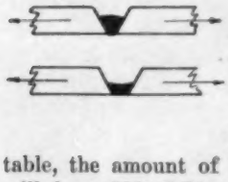


Fig. 4(b). When the Weld Groove Is Not Filled, Stresses Concentrate in the Weld.

table, the amount of heat in the plates will be: $890 \times 1.31 = 1170$ cal. If this heat has occasion to spread evenly over the plates, it will cause a temperature rise which may be calculated from the weight of the plates (156 kg.) and the specific heat of the steel (0.115 kg.-cal./kg./°C.), thus:

$$t = \frac{1170}{156 \times 0.115} = 65.5°\text{C.}$$

If the plates are free to move, they will shrink during the cooling. The steel having a linear coefficient of expansion of 11.65×10^{-6}, the shrinkage will be $\Sigma_1 = \frac{2000 \times 11.65 \times 65.5}{1{,}000{,}000} = 1.53$ mm. The same amount of shrinkage would have occurred if we had assumed other lengths L_1 of the plates.

If the plates have fixed ends, they will not be able to shrink, and therefore the cooling will cause a stress of the magnitude $\sigma_1 = \frac{E \times \Sigma_1}{L_1} = \frac{21500 \times 1.53}{2000} = 16.5$ kg/mm.². (23,300 lb. per sq. in.). (In this equation the value 21,500 is the modulus of elasticity E expressed in kg./mm.²)

In Germany, Lottmann has measured the stresses with extensiometers on plates having dimensions as above, the ends fixed by being welded to a thick armor plate and the single-V seam in the middle welded continuous across the plate with bare electrodes, and found a mean stress of 18 kg./mm.² Therefore, there is a good agreement between the calorimetric calculations and the values measured by Lottmann.

Welding of Patches Produces Unduly High Stresses

Since the stresses $\sigma_1 = \frac{E \times \Sigma_1}{L_1}$ resulting from welding as above are in inverse proportion to the length between the fixed ends, they will be greater the shorter this length and, with short fixed lengths, will exceed the yield point of the steel. A most difficult task, therefore, is to weld a small patch into a large plate as indicated in Fig. 4(a). One may proceed in the following manner: The plate patch is at first fixed in its correct position by thin tack welds. Then weld the edges 1 and 2, during which the edges 3 and 4 have an opportunity to move. Now wait until the whole plate is completely cooled.

When welding the edges 3 and 4, one must provide for a relief of the shrinkages: Either the patch is bent before welding, as shown, and then it will straighten during the cooling and shrinkage, or the weld is stretched through peening.

The peening may be accomplished in two different ways: either by welding short sections of the joint, one at a time, and hammering the weld while it is still at a red heat, or by welding in two or more layers and peening each layer as it is cooled below the blue-heat range of the steel. In the first case the weld metal has to be forgeable—in the other ductile also, at ordinary air temperatures—to obtain good results. The corners of the patch and opening should preferably be rounded to prevent the concentration of stresses at these locations. To avoid dangerous shrinkage stresses, we formulate the rule:

4. *Arrange the welding of the pieces so that they have, as long as possible, freedom to move in one or more directions,* avoiding insofar as possible the condition of fixed ends.

Shrinkage Stresses Concentrate in Partly Filled Weld Grooves

Most dangerous are the shrinkages when they become concentrated in the weld groove itself, as for instance through failure to fill completely the weld-groove as shown in Fig. 4(b), and then cooling. The weld being the weakest point in this case, the yield point of the weld metal will be exceeded and the elongation will mostly take place over the small width of the groove. The weld may then often fracture, the most dangerous cases being those where the cracks are so small that they are difficult to observe. Where we have the condition of fixed or partly fixed ends—and we always have to reckon

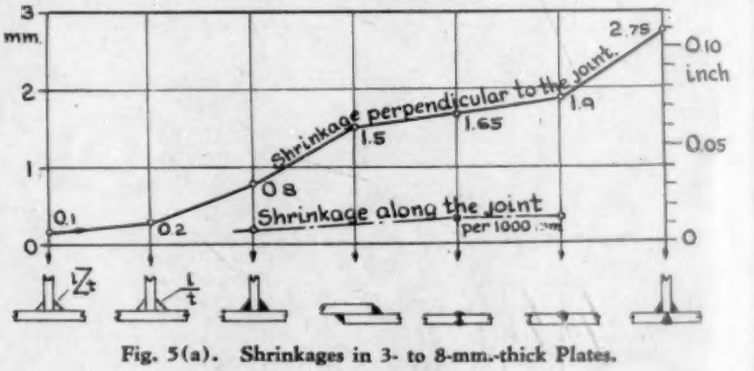


Fig. 5(a). Shrinkages in 3- to 8-mm.-thick Plates.

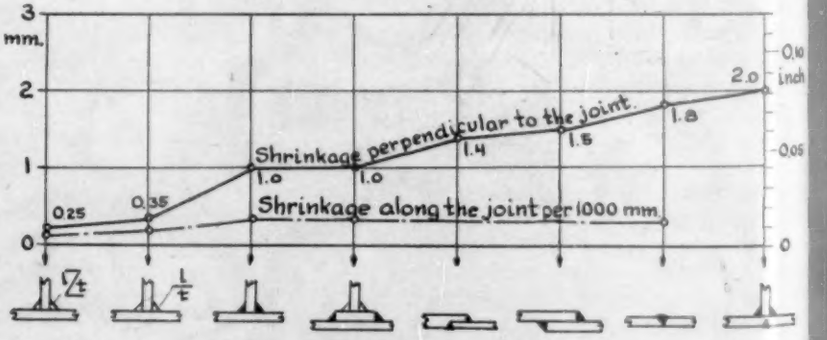


Fig. 5(b). Shrinkages in 12-mm.-thick Plates.
Ref.: Lottman, in *Schiffbau*, Nos. 13, 14, 15 and 16, 1932.

with partly fixed conditions for work pieces of large dimensions—we should comply with the following rule:

5. *Never leave a piece being welded for a long period of cooling unless the weld is built up to the full plate thickness.*

If the plates do not have fixed ends, as so far assumed, they will shrink. Both Owens and Lottmann have measured the shrinkages occurring through the welding of different joints with bare electrodes. Fig. 5(a) shows mean values for 3- to 8-mm.-thick plates, and Fig. 5(b) values for 12-mm.-thick plates. The shrinkage transverse to the joint is very slight if structural shapes are welded to the plates with staggered or chain welds, but considerably larger if a continuous weld on each side of the shape is used. The transverse shrinkage in the case of a lapped joint is somewhat less than with a butt joint. For other methods of welding than those used in the above tests, particularly with other electrodes, electrode diameters, welding currents, and amount of weld metal, the values of shrinkages may differ, and have to be determined by special tests. These diagrams, however, do give an idea of the approximate values to be used for laying off, erection, etc.

As will be seen in Fig. 5, the shrinkages in the case of butt joints generally are somewhat greater for the thicker than for the thinner plates. The following table shows that the amount of weld metal increases more rapidly than the increase in plate thickness:

Amount of Weld Metal in Single-V Butt Weld.

Germanischer Lloyd

t	a	b	Weld metal, kg./m. seam	
mm.	mm.	mm.	Theoretical	Practical a + 1 mm.
4	1	1	0.127	0.166
5	1	1	0.194	0.241
6	2	1.5	0.323	0.382
7	2	1.5	0.406	0.472
8	2	2	0.53	0.63
9	2	2	0.63	0.72
10	2.5	2	0.80	0.89
11	2.5	2.5	0.97	1.05
12	2.5	2.5	1.11	1.22
13	3	2.5	1.30	1.42
14	3	3	1.52	1.65
15	3	3	1.72	1.86
16	3	3	1.90	2.05
17	3	3	2.10	2.26
18	3	3	2.26	2.45
19	3	3	2.45	2.62

Thick Plates Impart a Degree of Fixity

The increase in values of shrinkage does not, however, occur as rapidly as we might expect, in view of the amounts of weld metal needed. The most probable reason is that the thicker plates, on account of their weight and rigidness, impart to the weld a sort of partly fixed condition, even when the plates are welded unrestricted; the welding zone, consequently, being stretched plastically through the range of 500° to 700°C., approximately, instead of being free to shrink.

Generally we may favor such a partly fixed condition if we wish to reduce somewhat the shrinkages, to obtain better fitting during erection or to reduce dents and warpage. A partly fixed condition may be executed by loading with weights, by wedging the plates loosely together, or by using tack welds. Therefore, we formulate the following rule:

6. *The shrinkages may be decreased somewhat by employing a partly fixed condition,* obtained for instance by weights or tack welding.

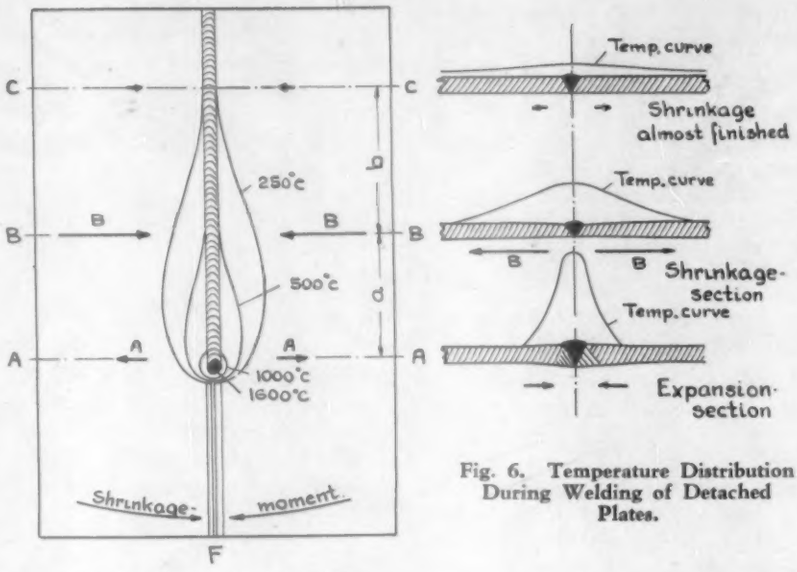


Fig. 6. Temperature Distribution During Welding of Detached Plates.

Shrinkages Perpendicular to Seam Increase in Direction of Welding

The shrinkages or stresses in the direction perpendicular to the seam will be of constant size measured along the seam only when the heating takes place simultaneously over the whole length of the seam. As the arc welding does not take place instantly, but progressively, the distribution of the stresses along the length of the seam will be uneven. If we have plates with fixed ends and weld continuously from one end of the seam to the other, the shrinkages and fixed ends will cause the distribution of the stresses over the length of the seam to be trapezoidal, and greatest in the end which is last welded.

On account of this uneven shrinkage, we get stresses also in plates which are being welded detached. Fig. 6 illustrates the condition when welding two detached plates, mostly according to the presentment of Lottmann. The molten material under the end of the electrode has a temperature of at least 1600°C. The material just around the spot being welded is being heated (1) from this molten steel, (2) from the welding current in the plate, and (3) from the heat of radiation from the arc. The temperature disperses gradually into the plate, as indicated by the isotherms, or curves of equal temperature. At the right the temperature curves are drawn for three sections. In section A-A, just behind the electrode, heat is constantly being added to the material, and next to the weld this material is very plastic and therefore during the expansion will be upset by relatively small forces A.

Farther back in the welded part of the seam, the heat conveyed from the spot being welded decreases, until we arrive at a section B-B where the loss of heat due to radiation and convection exceeds the heat being added and the material consequently starts shrinking. The temperature of the welding zone here has decreased considerably; the material may not be easily deformed any more, and if prevented from deforming freely, strong shrinkage forces will occur.

Rapid Welding Counteracts Tendency of Plates to Overlap

At section C-C, the cooling and shrinkage have either come to an end or are taking place much more slowly than at B-B. This part of the plate, therefore, will resist the more intense shrinkage at B-B, hence resulting in shrinkage forces B. The moment of these forces about C-C will be $B \times b$, the expansion forces at A-A having a moment of opposite direction, $A\ (a + b)$. Experience teaches that with slow welding the moment $B \times b$ will predominate, creating a strong tendency to bring the plates together at F. With very rapid welding—for instance, such as may be obtained by automatic welding—the moments $B \times b$ and $A(a + b)$ will be approximately equal. It is therefore of advantage to employ rapid welding, as already stated in Rule No. 3.

The shrinkage forces and moments which arises through the welding of detached plates will cause tensile and compression stresses in the plates. What is the distribution of these stresses by various methods of welding? As a general but not absolute rule we might say that in those parts which are *last* cooled we will have tensile stresses, their shrinkage

being prevented from the bordering cold parts of the plates.

In Fig. 7(a) the plates are placed with a certain wedged opening, the distance x having to be greater, the slower the speed of welding. As we weld continuously from A to B, the plates, on account of the shrinkage moment, have a tendency to close at B, and we prevent such movement through loading with weights or other means.

Welding Sets Up Compression Stresses Along Middle of Seam

Upon starting the welding at A, the plates here will shrink together as the weld cools. As welding progresses, we may, in the part of the seam which is completed, conceive the following picture of stresses: In the part just behind the electrode, where the welding zone is cooled rapidly, tensile stresses arise which will try to draw the plates together. The part of the welding zone further behind, which is already cooled, will resist this tendency and in so doing receives compression stresses. Finally, tensile stresses due to shrinkage may cause tensile stresses at A, acting as a lever with the cooled part of the weld as a fulcrum. Point B, being cooled, at last will possess tensile stresses. The final distribution of the stresses after cooling will then be as shown—with compression stresses, and therefore for thin plates a dent, at the middle of the plate.

The tacit presupposition for our reasoning was that the welding zone cools as the welding progresses. This will most nearly be the case with very thin plates and very long seams.

With thick plates, on the other hand, the heat conductivity into the plate is more intense and the loss of heat to the air slower in comparison. The heat gets more time to spread, and the final cooling may take place from the circumference of the plate and inward. In that case, the middle of the plate being cooled last will possess tensile stresses, or just the opposite of the state for very thin plates.

How should the plates be welded to decrease dents and stresses? We must provide:

(1) That the heat be distributed as evenly as possible over the length of the seam.

(2) That the plates, as long as possible, have a chance to move.

The last provision is best accomplished by starting the welding in the middle of the seam and welding towards the ends, or by welding from one end to the other. It is not favorable to start welding at the ends of the seam and weld towards the middle.

For arc welding, the plates generally are placed in their correct position and tack welded, instead of employing the method of wedged opening as shown in Fig. 7(a). The tack welds should be so weak that they crack under greater loads and thus allow the material to move a little and so adjust itself; and they should be so thin that they melt when the seam is being welded over them. For shipbuilding, tack welds ⅜ to ¾ in. long, made with small-diameter electrodes, and spaced 4 to 8 in., will generally prove to be satisfactory.

Dents Can Be Decreased by Distributing Heat Evenly

It was stated that for thick plates, the first provision to decrease dents and stresses is to provide an even distribution of the heat over the length of the seam. This may best be fulfilled by welding from the middle of the plate and outward, as shown in Fig. 7(b). One may weld at first from Z to B and then from Z to A, or two men weld simultaneously from Z outward toward A and B. For relatively thick plates and a seam not too long, this method will place the final heat at the points where the cooling is most intense—namely, at the ends—and therefore gain a more even shrinkage. The method is good for welding the end connections of plates over ¼ in. thick and not too wide. In the case of very thin plates and long seams, the cooling will have a more pronounced tendency to take place as the welding advances, and therefore will first occur in the middle of the plate, where we started welding; this may cause compression stresses and a dent in the middle of the plate, as indicated on Fig. 7(b).

For thin plates or long seams, we may distribute the heat better by welding by the step-back method, as shown in Fig. 7(c). We weld first from A to B, then from C to A, from D to C, and finally from E to D. While we are welding from C to A, the already welded part of the seam AB will be considerably cooled and the shrinkage of the part CA will cause compression stresses and eventually a small dent at A, as shown. After welding, we get therefore an alternation of tension and compression stresses in the plates, and possibly small dents. We also may find that there is a tendency to form a bigger dent towards the middle of the plate, depending on the length of the steps and on the thickness of the plate. Such a dent may be similar to that described for plates welded from one end to the other without step-backs, but much less pronounced. This bigger dent may be due not only to the stresses perpendicular to the joint, which we are now considering, but also to the stresses in the direction of the joint, which will be dealt with later.

With appropriate short step-backs of about 6 to 8 in. in length, the small dents and also the bigger dent mentioned will be reduced to the minimum and will appear eventually only in the case of very thin plates. We have reason to expect that the size of the tension and compression stresses will likewise be smaller.

Step-Back Methods Can Be Applied to Multi-Layer Welding

For welding in more than one layer, we may use the methods indicated in Figs. 7(d) and 7(e). The numerals denote the sequence of the individual steps and the arrows indicate the direction of welding. In Fig. 7(d), the first layer is completed, and then the second layer is welded in the opposite direction. Fig. 7(e) shows another method by which the weld is built up as the welding advances.

The method in Fig. 7(e) is to be recommended for long seams which are welded in cold and windy weather, or for long welds in fixed plates when hammering cannot be resorted to. With the step-back method, also, it may be favorable to let two men start simultaneously

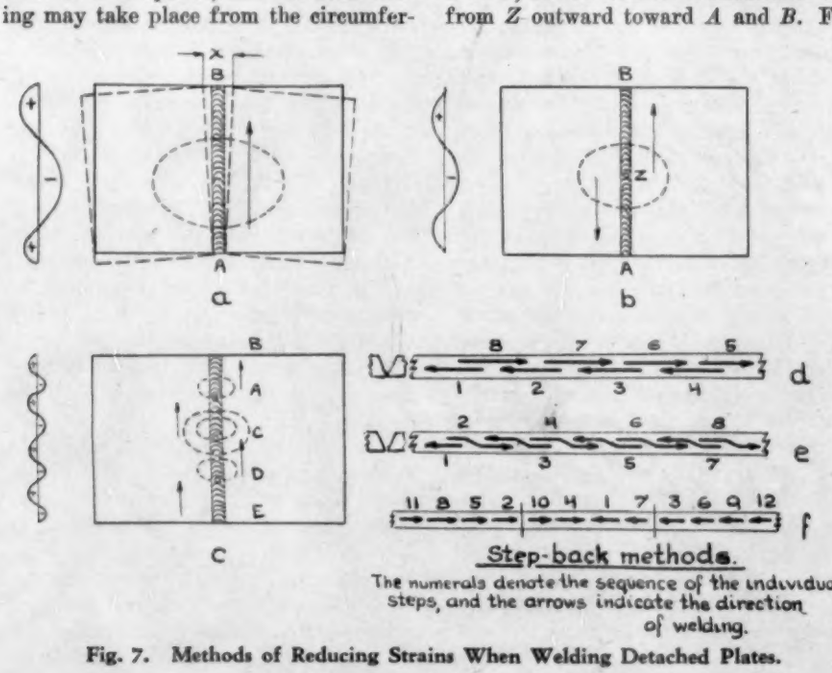


Fig. 7. Methods of Reducing Strains When Welding Detached Plates.

at the middle of the seam and weld towards the ends.

A still better distribution of the heat over the length of the seam may be obtained by dividing the seam into several parts and then jumping from one to the other, following a certain system—for instance, as shown in Fig. 7(f).

We sum up our knowledge in this rule:

7. *Distribute the heat over the length of the seam, when welding structures of large proportions, through step-backs and other methods.*

Slow Cooling Allows Better Distribution of Stresses

The most even distribution of the stresses will be obtained with a slow cooling of the material *after its temperature is below a red heat,* leaving time for the heat to soak into the plate.

In Fig. 8 are shown curves representing the loss of heat in kg.-cal. per m.² per hour, separated into radiation losses and convection losses with various velocities of air passed the plate, at an air temperature of 10°C.(50°F.), and as a function of the temperature of the plate. To cover a sufficient range of temperatures, the diagram is drawn with logarithmic scales on both axes, and it is therefore necessary to note the numerical values to judge the relative proportions of the losses of heat. We observe that at lower temperatures, convection is the dominating factor in the speed of cooling, especially if the air moves, as indicated for a slight breeze (5 m. per sec.) and a brisk breeze (10 m. per sec.). Therefore, we formulate the rule:

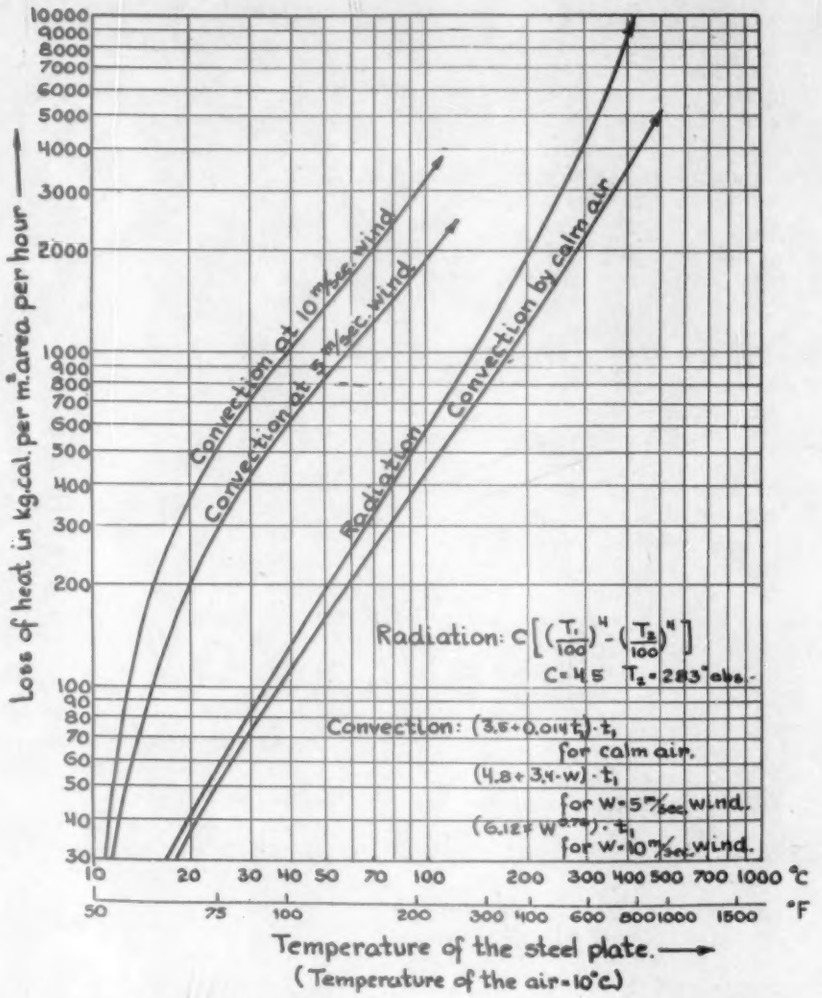

Loss of heat in kg.cal. per m.² area per hour
Convection at 10 m/sec. wind
Convection at 5 m/sec. wind
Radiation
Convection by calm air
Radiation: $C\left[\left(\frac{T_1}{100}\right)^4-\left(\frac{T_2}{100}\right)^4\right]$
C = 4.5 T_2 = 283° abs.
Convection: (3.5+0.014 t_1)·t_1 for calm air.
(4.8+3.4·w)·t_1 for w = 5 m/sec. wind.
(6.12+$w^{0.78}$)·t_1 for w = 10 m/sec. wind.
°C
°F
Temperature of the steel plate.
(Temperature of the air = 10°C.)

Fig. 8. Loss of Heat Through Radiation and Convection at Various Temperatures.

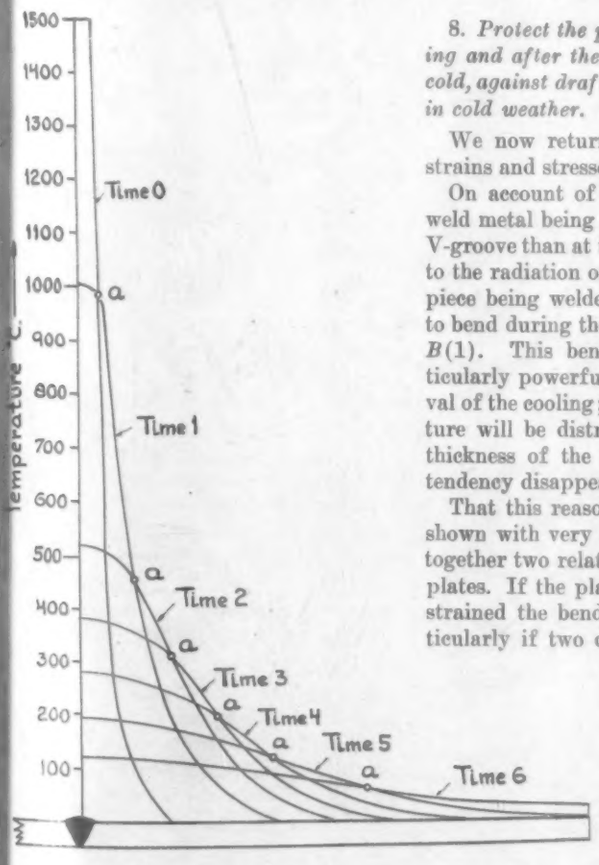


Fig. 9. Temperature Curves During Cooling.

8. *Protect the parts being welded, during and after the welding until they are cold, against draft and wind, particularly in cold weather.*

We now return to Fig. 1 to discuss strains and stresses as shown at *B* and *C*.

On account of the greater amount of weld metal being added at the top of the V-groove than at the bottom, and also due to the radiation of heat from the arc, the piece being welded will have a tendency to bend during the shrinkage as shown in *B*(1). This bending-shrinkage is particularly powerful in the first time interval of the cooling; gradually the temperature will be distributed evenly over the thickness of the plate and the bending tendency disappears.

That this reasoning is correct may be shown with very simple tests: We weld together two relatively narrow and short plates. If the plates are loose and unrestrained the bending will be great, particularly if two or more layers of weld metal are applied. On the other hand, if we place weights on the plates as indicated in *B*(2), the bending, after welding is completed and the weights removed, will be small or entirely lacking when welding with one layer only, and also when welding with more than one layer it will be considerably less than for unrestrained plates. Consequently, the bending stresses which arise if we force the plates back into a plane will be less by weighted than by loose plates—and these stresses are identical with those which will exist in the plates if secured in their plane after welding.

Welding in Thick Layers Reduces Bending Stresses

Therefore, we may recommend that welding be done in such thick layers that the temperature is allowed to become evenly distributed over the thickness of the plate before the weld is cooled below a red heat. Then follow with Rule No. 6 and decrease the shrinkages and stresses by some kind of partly fixed condition, which may be executed by loading with weights, wedging or tack welding. In the case of long welds, step-backs will act as a restriction, because the cooled welded steps oppose the bending of the plate.

In Fig. 1, *C* refers to the shrinkages and stresses occurring longitudinally to the welded seam. For the same reasons as just mentioned for the shrinkages perpendicular to the seam, the plate will have a tendency to bend as shown in *C*(3). The means of counteracting this bending are also the same as those given for bending as in *B*(1)—that is, welding in relatively thick layers so that the temperature distribution over the thickness of the plate is as even as possible before the welding zone is cooled below a red heat, and fixing the plate so as to prevent bending during this period. Hence, we formulate the following rule:

9. *To prevent bending of the plate, weld if possible in such thick layers that the reverse side of the plate is assuming a red heat during welding. Use some means of restriction against bending.*

Finally, we shall investigate shrinkages and stresses as shown in *C*(1) and *C*(2), Fig. 1. As long as the welding zone is very hot and the surrounding material cold, shrinkage along the weld will encounter great resistance; the welding zone will therefore receive mostly plastic deformation all the way down to about 500°C. The curves in Fig. 9 illustrate the state of temperature in a section perpendicular to the weld at different time intervals during the cooling. To the left of points *a*, the material is cooling, and tensile stresses will develop in this part. To the right of points *a*, the material is still being heated, and the expansion will cause compression stresses in this part, since expansion is prevented by the material which is shrinking at the middle of the plate as well as by the cold material at the edges of the plate. Points *a* during the cooling will move out towards the plate edges, and the edges, therefore, after they have finished cooling, will have compression stresses, whereas the weld and a narrow zone on each side will possess great tension stresses.

Shrinkages Are Not so Great in a Direction Along the Weld

In consequence, the shrinkages longitudinal to the weld will be far less than those perpendicular to the weld. This is shown in Figs. 5(a) and 5(b). This fact has a great practical bearing, and teaches that, in the sequence of erection it is very important to weld first, while the parts have still freedom to move, those joints which cause great shrinkage and then those causing less. Hence, the rule:

10. *Weld, in general, at first all end connections of the plates and then the seams. Also weld at first transverse joints in the shapes, if such occur, and then weld the shapes to the plates with intermittent fillet welds which cause very slight shrinkages only.*

Usually the welders should work in pairs, starting welding at the middle of the ship and moving towards the ends. Preferably, welding should be performed simultaneously at the starboard and at the port side of the hull.

(*Second or concluding article will appear in March issue.*)

Applying Titanium to Welding-Rod Coatings

By L. G. BLISS
Laboratories of the Foote Mineral Co.

Titanium dioxide holds a prominent position in welding-rod coatings as an arc stabilizer, some coatings containing as much as ten parts of TiO_2. Owing to the relatively high price of the 98% grade of TiO_2, manufacturers of coated welding rods have sought for a more economical substitute.

Of the substitutes, Ilmenite, an ore containing 52% TiO_2, has been found suitable in a few cases where the coating also contains a percentage of Fe_2O_3, but of the less expensive ores, Rutile is by far the most popular. A good grade of Rutile contains about 96% TiO_2, and its remaining 4% is composed of SiO_2 1%, Fe_2O_3 1.6%, P less than 0.5%, S less than 0.2%, and the balance of Al_2O_3, CaO, MgO. The impurities are not objectionable in most cases. It was long considered that the presence of phosphorus and sulphur, even in such small percentages, would impair the general workability of the rod; and although some still feel that laboratory evidence substantiates such an impression, many good rods on the market today contain a large percentage of Rutile in their coatings. Through the use of Rutile, the cost of the TiO_2 content of the rod may be diminished about one-third.

While the color of a rod has no influence upon its performance, sales resistance increases with the variation in shade of the coating. The general feeling has been that ores such as Rutile would produce such a variation in shade, but it has been demonstrated that the objection may be eliminated by standardization of the ore.

Recently, considerable attention has been given calcium-titanium silicate. This compound has an average analysis of 40.8% TiO_2, 30.6% SiO_2, and 20.6% CaO, with traces of yttrium. Its predicted importance embodies economic, physical and chemical advantages. It is expected that by the use of calcium-titanium silicate a more brittle and easily fusible slag will be obtained, in addition to a more economical source of TiO_2. Work done with carbon electrodes indicates that yttrium present in extremely small percentages enhances the stability of the arc, but whether a trace of yttrium has any influence on arc stability in welding-rod coatings, has not as yet been determined.

It is expected that the applicability of this new material to coatings may be definitely established very shortly.

Chicago Selected for Next Metal Congress

The National Metal Congress and Exposition will be held this year in Chicago, during the week of Sept. 30th, the exposition holding forth in the new International Amphitheater. The fall meeting of the American Welding Society will be held in Chicago during the same week, action toward that end pending approval by the directors of the recommendations of the Manufacturers Committee. The Palmer House has been selected as headquarters.

Polariscope Demonstrated at San Francisco Meeting

The December meeting of the San Francisco section of the American Welding Society, held at Athens Hall, in Oakland, was of an unusually interesting character. An important paper on the "Economics of Welding," by S. Corzo, of the Western Pipe & Steel Co. dealt with structrural welding of pressure vessels, maintenance, and pipe welding. A demonstration of the polariscope was given by S. H. Taylor, of The Lincoln Electric Co., who showed how stresses can be measured and the effect of surface contour on stress concentrations.

New I. C. C. Regulations Affect Highway Carriers

Regulations for the transportation of explosives and other dangerous articles (including compressed gases) on public highways by motor truck or other vehicle, including specifications for shipping containers, have been issued by the Interstate Commerce Commission, and become effective on March 1, 1935. Copies of these regulations may be obtained from the Secretary of the Commission, at Washington, D. C.

Commenting on these new regulations a recent *News Bulletin* of the Compressed Gas Manufacturers' Association, Inc. says: "This is the first step in the effort to control the transportation of dangerous articles by any means of transportation. Uniform regulations will now affect transportation by rail and truck in interstate commerce and by water. These regulations all require compliance with the I.C.C. cylinder specifications and maintenance regulations. The second step, and one that is now pending action, is the adoption of trucking regulations by each State Legislature to govern intrastate movement. When the latter are adopted, legislation will be in effect to require uniform specifications for container construction and regulations for their maintenance. Any attempt to transport non-complying containers would then constitute a violation of a Federal or a state law."

Zero Weather Cuts Down Conference Attendance

Under the worst of weather conditions, with the thermometer way below zero and the roads covered with a solid sheet of ice, the 7th annual welding conference of Iowa State University was held at Ames, Iowa, on Jan. 23rd to 25th, with a total registration of 261, just ten less than at the 1934 conference. Exhibits were given by 27 manufacturers and sales agencies of welding equipment and supplies. The banquet, which has become an annual affair, was attended by 129—a good gain over the 104 who attended last year's feast.

'Quake-Damaged Structure Reinforced by Welding

The Los Angeles Gas & Electric Co. recently completed a large welding job at Seal Beach, where extensive welded structural-steel reinforcing has been placed in the company's large steam plant, which was badly damaged by the earthquake of March, 1933. The entire plant was completely overhauled and reinforced throughout. The reconstruction program required over a year for completion and employed a large force of welders. Much of the work was done where the heat was almost unbearable to the welders, the temperature ranging from 120° to 140°, or even greater, and making it necessary for the operators to relieve one another every few minutes to avoid illness.

British Institute to Hold Welding Symposium

A symposium on the welding of iron and steel will be held by The Iron and Steel Institute (British) in the lecture theater of the Institution of Civil Engineers, Great George St., Westminster, S. W. 1, London, England, on May 2nd and 3rd, in conjunction with the annual meeting of the Institute.

The general objects of the symposium have been announced to be as follows: (a) To review the position of welding in all its industrial aspects, both in Great Britain and in other countries; (b) to obtain knowledge of the problems encountered in welding as employed by the various industries in Great Britain and in other countries; (c) to reveal what research work has been or is being undertaken, and (d) to consider the advisability of taking steps to coordinate research work and to stimulate and guide future research.

K. Headlam-Morley, secretary of The Iron and Steel Institute, 28, Victoria St., London, S. W. 1, will be glad to supply information about the symposium, and to receive offers and suggestions regarding papers, and applications to take part in the proceedings.

A Welding Engineer's Wife Speaks Her Mind

■ By ONE OF 'EM

Persian Honeymoon

Welding interests have taken a young Cleveland couple to make their home in the Near East. Miss Lydia M. Lewis journeyed to Cairo, Egypt, to meet her fiancé, Bernard J. Brugge, and their marriage took place at the American mission there, January 11. The newlywed couple then left for Abadan, Persia, where Mr. Brugge is welding engineer for Anglo-Persian Oil Co. The company has built a bungalow settlement for its engineering forces, and the bride is the only American woman in a colony of five hundred Englishwomen.

Average temperature at Abadan is 110°, coolest, 70°. Mr. Brugge, a graduate of Purdue University, spent a year at Abadan in the interest of an American equipment firm before he joined the pipeline construction forces of the British concern. Mr. and Mrs. Brugge may be addressed at Abadan, Persia, Persian Gulf, care of Anglo-Persian Oil Co.

The lure of these far-off jobs is great, but sometimes the hardships actually encountered detract somewhat from their glamor. This phase of engineering construction in the Near East is discussed in a letter recently received by Mr. A. F. Davis, vice-president, Lincoln Electric Co., from his firm's British sales agent, Mr. R. M. Gooderham, London. If anybody thinks the British lack humor, he should read the following excerpts which I have permission to quote:

"You can get a native welding operator for 25 cents a day, but he is not such a bargain at that. A Persian native tried to weld a leak in an acetylene generator. The Mohammedan belief, that a person cannot enter Paradise if any part of his body is missing, resulted in a week's search on the part of the man's family, trying to find all the pieces of him for burial. . . . Natives like to tell other people how to do things. (A nation of kibitzers.—Author's Note.) A stranger is likely to step out of the blue any time and start telling a gang of coolies what to do. Nobody pays any attention, and nobody minds. The same in the bazaar. If you wander into a shop and are seen talking with the proprietor, usually two or three natives rush in from the street and take charge of the selling. . . . Another playful habit of the natives is stripping clothes off people. On one occasion a truck driver appeared clothed in an old piece of carpet. . . . The pipeline workers had the Mohammedan Friday off instead of the Christian Sunday, and as the men would paint things red on Thursday nights, they would have to spend their holy day in the hoosegow, and the company had to send its truck to jail Saturday mornings to pick up its working forces. . . . When rounding up the men for work on the pipelines, it often turned out that several innocent bystanders had been hauled to the job along with the workers. It was found that they had just gone along for the ride. . . . The new 147-mile, 3-inch oil pipeline from the Naft-i-Shah oil fields and tapping plant to Kermanshah, being built to supply oil to northern Persia, is scheduled for completion during the summer of 1935. Due to the rugged country, trenches must be dug by manual labor. Pipe is buried two feet deep, but first it is wrapped with felt and covered with bitumen."

• • •

A Pair of Boneheads

An old Chicago friend spent a recent weekend with us—that grand person, Oliver A. Mitchell, president, Mitchell Engineering Co. His firm does expert boiler-repair work in the Chicago district. Clients include several churches, and Mr. Mitchell revealed that two sects are particularly nice to deal with—the Catholics and the Christian Scientists, for they are prompt in financial matters.

We related to Mr. Mitchell a recent harrowing boiler experience of our own. Fact is, I had let the steam boiler in our home go without water for three days, while preoccupied with other matters. My husband was away, and I got panicky and let a flood of cold water in on the red-hot boiler plates. A large crack resulted. There must be a special providence that looks after women like me, for I am informed that my procedure was extremely dangerous. I summoned my husband by telegraph, and when he arrived he had the boiler welded and *then* flooded with boiler compound. I could not understand why both of these operations were necessary. To a woman, that seems like a man's wearing belt and suspenders at the same time. The men spent hours trying to explain it to me, but I am still foggy about it all.

Anyhow, my predicament reminded Mr. Mitchell of a business experience he had recently. Called by a laundry engineer to repair a leaky tube in a firebox boiler, in the course of his inspection Mr. Mitchell noticed a mud-bag about the size of a derby hat in the crown-sheet of the boiler. He asked the engineer if he didn't want the mud-bag cut out and patched. "No, leave that alone!" the engineer shouted, "the manufacturer put that in there to catch the mud." Mr. Mitchell's reply was that he had better haul the fire, blow down the boiler, and get the h— away from there or he would be going places all of a sudden.

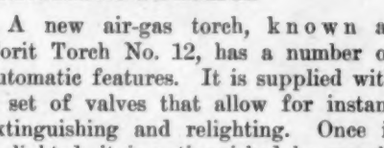
Maybe you fellows will understand this, but I don't.

What's New in

Equipment and Accessories

New Air-Gas Torch Has Automatic Features

A new air-gas torch, known as Torit Torch No. 12, has a number of automatic features. It is supplied with a set of valves that allow for instant extinguishing and relighting. Once it is lighted, it is extinguished by merely releasing the long lever, and it is instantly relighted when the torch is picked up and put to work.



Lever Control Provides Automatic Extinguishing and Relighting.

This automatic torch is recommended for soldering, heating, core drying, and for many other applications where localized heat is wanted. It is especially designed for production work. Natural gas or manufactured gas, together with compressed air, may be used. Full information can be obtained from the Torit Manufacturing Co., 170 West 3r St., St. Paul, Minn.

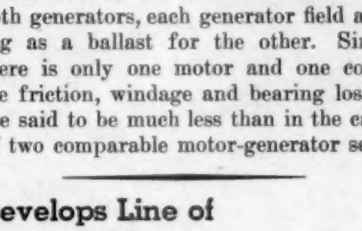
Two Welding Units With One Motor and Exciter

Two welding generators, mounted integrally with a common driving motor and exciter, has been developed by the Electric Arc Cutting & Welding Co., Newark, N. J., and the Star Electric Motor Co. This machine, known as the "Star-Dualarc," is available in three sizes: 400 amperes (two 200's), 600 amperes (two 300's) and 800 amperes (two 400's). The patented cross-connected series-field system allows both generators to be operated as a single unit to deliver a high current for heavy work. Each generator, operating individually, has the full power of the double-strength motor to get the arc over the "tough spots."

One exciter delivers field current to both generators, each generator field acting as a ballast for the other. Since there is only one motor and one core, the friction, windage and bearing losses are said to be much less than in the case of two comparable motor-generator sets.

Develops Line of Small C-Clamps

A line of "Pony" miniature C-clamps, having 1-in. depth of throat and opening 1 and 2 in., are now available from the Adjustable Clamp Co., 417 N. Ashland Ave., Chicago, Ill. These clamps have frames of high-quality malleable iron,



"Pony" Miniature C-Clamp.

and are well proportioned to obtain high strength. The "foot" is ground smooth and is cadmium plated. The steel screws have standard threads, and are tipped with freely turning swivels, deeply riveted. The loose-pin handle permits ample pressure to be applied, even in close quarters.

New Electrode for Restoring Cutting Edges of Tools

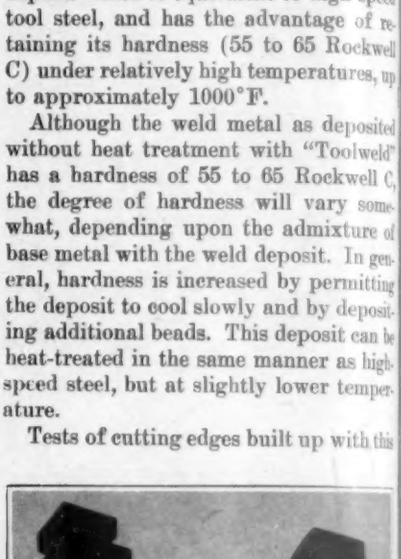
A new arc-welding electrode, which is designed for restoring worn cutting edges on tools of all kinds and is said to permit savings of 20% to 25% in tool cost, has just been announced by The Lincoln Electric Co., Cleveland, Ohio.

This new electrode, known as "Toolweld," is the product of several years of research. By its use, lathe tools, bits, milling cutters, drills, cutting and forming dies, and other tools which have become worn in service can be given a new cutting edge that is extremely hard and wear-resisting. Tools can be refaced an unlimited number of times with this electrode. Also, new tools using ordinary steel in place of high-speed steels can be provided with a cutting edge at tremendous savings.

The "Toolweld" electrode provides a deposit which is equivalent to high-speed tool steel, and has the advantage of retaining its hardness (55 to 65 Rockwell C) under relatively high temperatures, up to approximately 1000°F.

Although the weld metal as deposited without heat treatment with "Toolweld" has a hardness of 55 to 65 Rockwell C, the degree of hardness will vary somewhat, depending upon the admixture of base metal with the weld deposit. In general, hardness is increased by permitting the deposit to cool slowly and by depositing additional beads. This deposit can be heat-treated in the same manner as high-speed steel, but at slightly lower temperature.

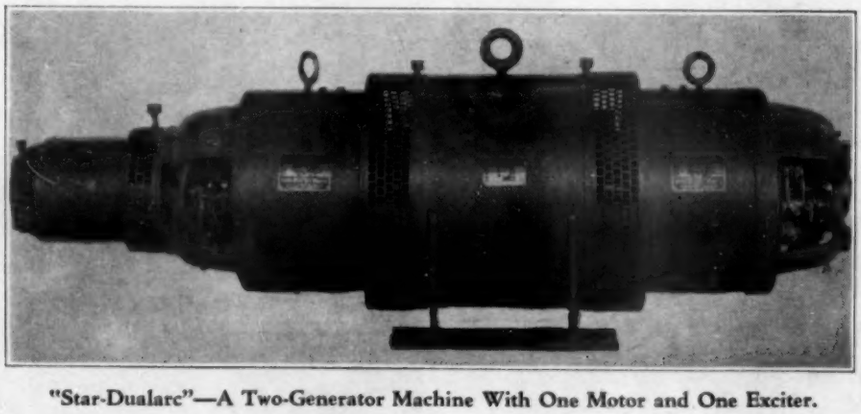
Tests of cutting edges built up with this electrode reveal results which are superior to those obtainable with ordinary tool steel.



Left—Deposit of "Toolweld" Before Grinding. Right—Same Tool After Severe Service.

In a recent experiment, a tool faced with this electrode was placed in a machine alongside a regular tool and used in turning down 20 shafts of motor-generators. As these shafts contained 0.20% to 0.30% carbon, they were more difficult to machine than would be the case with a harder steel.

With the tool faced with "Toolweld" 14 shafts were turned to a depth of 3/16 in., the length of cut being 15 in. Using the ordinary tool steel, 12-in. cuts 3/16 in.



"Star-Dualarc"—A Two-Generator Machine With One Motor and One Exciter.

deep were made on 6 shafts. In both cases, the operating speed was 117 r.p.m.

Inspection of the two tools at the end of the test showed that the one faced with "Toolweld" had a square, sharp edge, whereas the cutting edge of the ordinary tool steel had become rounded off. The illustration shows the deposit of "Toolweld" before grinding, and the same tool on completion of the test.

"Toolweld" is said to provide typically dense non-porous shielded-arc weld metal. The electrode is covered with a coating which, as it is consumed in the arc, shields the arc from the atmosphere and prevents the formation of oxides and nitrides in the weld metal. This coating also helps to steady the arc and insures a smooth, uniform weld deposit.

"Toolweld" electrodes are made in 14-in. lengths in four sizes—3/32, 1/8, 5/32, and 3/16 in. It comes packed in 5-lb. containers.

Hard-Surfacing Metal for Treating Steel Parts

Durox-S-20 is the name of a metal applied in rod form for increasing the efficient life of parts subject to great abrasive wear, such as grader blades, power-shovel teeth, plow shares, drill bits, dragline buckets, conveyor parts, pump impellers, and the like.

When applied to the base metal, Durox-S-20 penetrates by its own weight to the desired depth, becoming an integral part of the treated piece, it is claimed. Its specific gravity, 15.48, is nearly twice the specific gravity of steel.

Durox-S-20, when applied, is said to have 64 times more resistance to abrasion per square inch than high-carbon steel, and 1 lb. of the metal will penetrate approximately 64 sq. in. of surface. The metal retains all its characteristics, never reaching the completely molten state regardless of the amount of heat applied.

The treated portion may be dipped in oil or water immediately after Durox-S-20 has been applied, without cracking or chipping, it is said. Moreover, its wear-resisting qualities are unaffected, even though the base metal be heated and drawn out under a hammer after treatment.

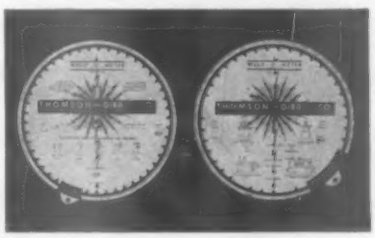
Durox-S-20 is prepared for application in granular form, placed in 1/4, 5/16, and 3/8-in. mild-steel tubes, which keep the granular particles from being blown away by the pressure of the arc or torch. It is applied the same as any other rod, by the oxyacetylene flame or by the carbon arc, using a sharp-pointed carbon pencil.

Further details can be obtained from the manufacturers, the Enterprise Foundry Corp., 2902 Nineteenth St., San Francisco, Calif.

Useful Chart Gives Data on Resistance Welding

The "Weld-O-Meter" is a quick-reference circular chart that gives the type of equipment and control settings to be used for spot or flash welding any gauge of metal at any required production rate. It has just been developed and issued by the Thomson-Gibb Electric Welding Co., of Lynn, Mass.

A single turn of the disc tells all of the information at a glance. On one side, the chart tells the type of welder required, the transformer capacity, the heat-regulator setting and the pressure needed to spot weld metals ranging from two thicknesses of 26 gauge up to two thicknesses of 1/4-in. stock, at production speeds of



One Side Gives Spot-Welding Data and the Other Side Flash-Welding Data.

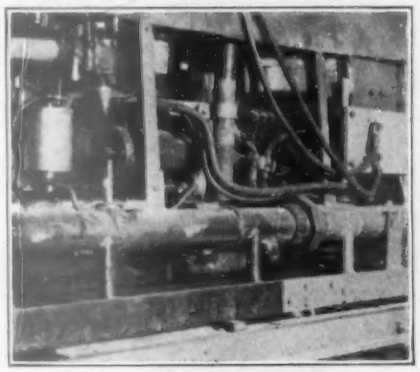
30 to 120 spots per minute for the lighter gauges and ranging to 5 to 20 for heavier stocks. The spot-welding chart also tells the current consumed per 1000 welds in kilowatt-hours and suggests an alternative welder for the same work.

The reverse side of the chart gives similar information about the equipment needed to butt or flash weld metals ranging from 0.01 to 2 sq. in. in cross-sectional area. Detailed information on the type of welder, the proper clamping and push-up devices, the transformer capacity, heat setting and push-up pressure, as well as the current consumed and the production per hour, is shown when the dial is set at the point on the chart which represents the area of the metal to be welded. Pictures of different types of welders are also shown on both the spot and flash sides of the "Weld-O-Meter."

Power-Shovel Teeth After Being Treated With Durox-S-20

Develops New Governor for Engine-Driven Welders

A new magnet-controlled governor for engine-driven welding generators is now being manufactured by the Electric Cutting & Welding Co., Bell, Calif. This governor, which can be applied to all



Governor Installed on Welder.

sizes of generators up to 600 amperes in rating, is said to decrease gasoline consumption and wear and tear on the engine as much as 50%. It is said to require no oiling or attention of any kind, and carries a guarantee by the manufacturer. V-belt drive is employed. Jake Underwood, proprietor of the Bell concern, states that several of these governors are in use in Arizona and Southern California shops and are highly satisfactory.

New Electrode for Automatic Metallic-Arc Welding

A wire for automatic metallic-arc welding, consisting of a solid metallic core surrounded by a woven wire mesh, the pockets of which are filled with flux to produce a shielded-arc condition during welding, has been put on the market by The Welding Wire Co., 28 Harvard St., New Britain, Conn., who sells it under the name Woven Welding Wire. This company has also developed an automatic feeding device for use with the wire. The device is operated by push-button start-and-stop control.

Current is fed from an auxiliary contactor, through the wire mesh, to the core. The mesh, which keys the flux to the electrode, allows the passage of high currents to the core at the contact point. The diameter of the weaving wire governs the total flux thickness; for example, weaving with 0.023-in.-diameter wire gives a total flux thickness of 0.046

in. entirely surrounding the core. The coating thickness, owing to the braided construction, is said to be uniform along the entire length of the wire.

Woven Welding Wire is recommended to be used with reversed polarity, it having a faster flow as a negative electrode than as a positive.

The contactor in the feeding device is of the toggle type, allowing free passage for foreign matter and insulating the mechanical control from the contactor as regards both current and heat, thereby giving long life to the mechanical members.

The tangential-grip feed rolls employed are said to be positive in feed and gripping action, and lessen appreciably the required pressure for feeding, thus eliminating roll slippage as well as possible distortion of the electrode in feeding.

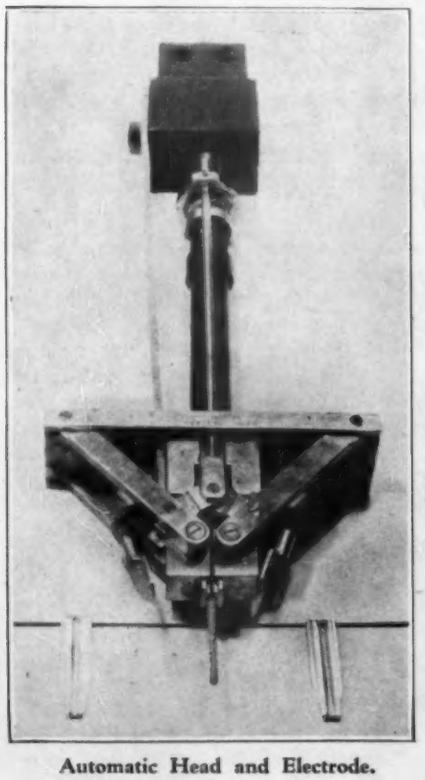
A single-adjustment, plunger roll type of straightener is included so as to eliminate the frictional wear on the contactor inserts, which are made of cadmium copper. An original set of inserts in operation for more than three months have shown no appreciable wear, it is claimed.

The take-off reel is a tapered-barrel all-steel demountable-rim reel, having thereon a sliding ground contactor, which makes use of the electrode coil as a high resistance to balance the variable resistance of the arc. This construction is said to reduce or eliminate arc blow, and allows current to be taken directly from the reel in case foreign matter should enter the contactor tips.

Welds made with Woven Welding Wire and electrode contactor apparatus show an ultimate tensile strength of 75,000 to 80,000 lb. per sq. in. and an elongation of 25% to 30% in 1 in., it is claimed. An actual test specimen made on ¾-in.-thick plate, two layers on a single pass, using a multiple-head automatic welding unit, tensiled 79,000 lb. per sq. in., with an elongation of 28.4% in 1 in. No cleaning of the resulting flux formation on the deposit weld was required between subsequent layers of the weld metal, as the flux produces a slag that is full floating and on cooling is self-removing.

This equipment is said to be adaptable to all standard automatic metallic-arc welding units, and requires no direct change in the unit construction.

Woven Welding Wire is furnished in coils having a tapered bore so as to be readily placed on the reel for use. A coil can be changed in less than a minute, as an average. Straightened and cut lengths of wire, packed in 50-lb. boxes, are available for manual welding. Standard stock diameters are ⅛, 5/32, 3/16, ¼ and 5/16 in.



Automatic Head and Electrode.

Emergency Carbide Light Always Ready for Use

A new carbide police emergency light, which weighs only 40 lb. when fully charged, and burns for three hours, giving 8,000 candle power, was recently announced by the National Carbide Sales Corp., Lincoln Building, New York City. Though known as a police emergency light, it has many other applications in the municipal, aviation, railroad and construction fields.

The reflector is mounted on a universal swing joint so the light may be shifted to any angle, and it may be easily folded down for carrying by a convenient handle above the carbide hopper. The unit is 3½ ft. high when extended for use, and 28 in. when folded.

A 1¾-lb. charge of carbide placed in the hopper is sufficient for over three hours. The light may be operated intermittently, as needed, without the waste of any of the charge. By throwing a lever, the carbide is released a few grains at a time into the water tank below, and the rate of feed of the dry carbide is regulated automatically by the gas pressure. The light may be shut off by throwing the lever back to the locked position. The tank is made of 18-gauge sheet steel, hot-dipped in lead after the tank is welded. No spilling if the light is turned over; it will go right on operating when set upright.

This Police Emergency Light Weighs Only 40 Lbs. Filled.

Announces a Flexible Aluminum Paint

A flexible aluminum paint, which gives a scale-like metal sheathing, plus a smooth, brilliant finish, was recently introduced by the Roxalin Flexible Lacquer Co., 800 Magnolia Ave., Elizabeth, N. J. Dirt and dust do not attach themselves readily to the surface, and it is easily washed. It is said to display great resistance against corrosion from water (including salt water), humid atmospheres, and chemical fumes. The one standard grade is recommended for both indoors and outdoors. Stained and discolored surfaces are said to be covered completely by one application.

Trade Literature

Manganese steel—its history, properties, manufacture, heat-treatment, machining, applications, and welding—is discussed in The Amsco Bulletin, of Jan., 1935, issued by The American Manganese Steel Co., 382 East 14th St., Chicago Heights, Ill. In the same pamphlet, manganese-steel renewable-lip dippers are described, applications of nickel-manganese steel welding rod are shown, and a description is given of the company's new x-ray installation for inspecting manganese-steel castings.

A new edition of the booklet on Enduro 18-8 stainless steel has been published by the Republic Steel Corp., Massillon, Ohio. Various steels of the 18-8 type are described, and a table shows the degree of corrosion-resistance exerted by 18-8 steels and two types of chromium steels in the presence of several hundred individual chemicals, solutions and other reagents. Copies may be obtained by asking for booklet No. 125-A.

The Ditwiler Split-Shaft Power Takeoff, which can be mounted on any truck for the purpose of driving a welder or other machine from the truck engine, is described and illustrated in

Constant Uniformity!

...one reason why TOBIN BRONZE is preferred by so many Welders

With so many varying factors in a welding job . . . *factors which must be controlled* . . . thousands of experienced welders refuse to take a chance on the quality of their rods. They ask for and get genuine Tobin Bronze.

More than a century of metallurgical experience accounts for the unvarying dependability of Tobin Bronze. And it has been tested thoroughly, not only in the laboratory but also on the job . . . on tens of thousands of jobs. It is universally used for the general oxy-acetylene welding of cast and malleable iron, locomotive cylinders, automobile engine blocks, cast iron pipes, machinery parts and similar equipment.

Don't gamble with an unproved rod. Ask for and get the original low melting point bronze rod . . . *genuine* TOBIN BRONZE . . . which carries the name stamped every 12 inches in each rod.

MELTING POINTS OF ANACONDA WELDING RODS

Material	Approximate Melting Point—Degrees	
	Cent.	Fahr.
Tobin Bronze* . .	885	1625
Manganese Bronze	870	1598
Brazing Metal . .	930	1706
Naval Bronze . .	885	1625
Everdur*	1019	1866
Phosphor Bronze A	1050	1922
Phosphor Bronze E	1070	1958
Phosphor Bronze D	1000	1830
Phosphor Bronze C	1025	1877
Silicon Copper . .	1083	1981
Deoxidized Copper	1083	1981
Electrolytic Copper	1083	1981
Nickel Silver . . .	1055	1931
Ambrac*	1150	2102

*Trade-marks Reg. U. S. Pat. Off.

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THE AMERICAN BRASS COMPANY
General Offices: Waterbury, Connecticut
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ANACONDA WELDING RODS

a leaflet issued by the Ditwiler Manufacturing Co., Galion, Ohio. The Redi-Service truck, equipped with welder and air compressor, also is described.

"Electrodes for making machinable cast-iron welds" is the subject of a bulletin outlining procedures to be used with "Nico," "Copper Arc," and "Arcast" electrodes and showing how to select the proper electrode for the work in hand. Copies may be obtained from C. E. Phillips & Co., 5443 Twelfth St., Detroit, Mich.

"Machinery Bases—a comparison of designs and costs" is the title of Application Sheet No. 41 of Series 2, issued by The Lincoln Electric Co., Dept. 241, Cleveland, Ohio. Cost comparisons are made between a cast-iron base and two designs of fabricated steel welded bases.

Draw-Cut Machine Tools for Industrial Shops, is the subject of a booklet issued by the Morton Manufacturing Co., Muskegon Heights, Mich., describing flash-trimming machines, shapers, planers, keyway cutters, and other machines.

Alternating-current welders of the motor-generator type, designated as types SAC300 and SAC400, are described and specifications given in Welder Specification Bulletin No. 308, issued by The Lincoln Electric Co., Cleveland, Ohio.

Literature on their new "Protected-Arc" welder and new electrode holder have been issued by the USL Battery Corp., Niagara Falls, N. Y. High arc stability and quick voltage recovery are illustrated by means of oscillograms. The fully enclosed construction is featured.

Methods for obtaining continuity for steel beams by arc welding and by reinforced-concrete construction, are detailed in Plate 48, of the series of Studies in Structural Arc Welding, issued by The Lincoln Electric Co., Cleveland, Ohio.

The index, issued yearly, to A. S. T. M. standards and tentative standards, is now available from the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa.

Portable track and bridge-welding units are described and shown in Bulletin GEA-2033, recently issued by the General Electric Co., Schenectady, N. Y.

Commercial News

Wayne Welding & Supply Co. Holds Monthly Clinics

A desire to promote something different from the usual welding school, or annual conference or "clinic," and to help business in the Fort Wayne territory, prompted James ("Red") McClure, president of the Wayne Welding & Supply Co., Fort Wayne, Ind., to establish monthly "clinics" at his plant. Accordingly, on Dec. 7th, he sent the following letter to every business concern and job shop in his section that he knew was using or contemplating using welding or flame cutting:

"Subject: Wayne Welding Co. opens clinic for study and practice of latest developments in welding.

"The opening of this clinic is perhaps the greatest forward step ever undertaken by our company.

"Realizing that the application of both gas and electric welding is only in its beginning, we have for some time operated an experimental and testing laboratory where practical tests are made in construction and maintenance work, in production work, and in general job shop practices. We felt that this practical and technical information was desirable for us to properly inform and assist our customers.

"But until now it was not possible for you to spend time in our shop studying and conducting practical tests on your own problems under our supervision and instruction. This step has now been taken because we believe that both gas and electric welding can be applied far more generally and profitably just as soon as those interested in manufacturing, maintenance and repair work know more about its application.

"The Wayne Welding Clinic gives you this real opportunity without cost, and we are anxious to have you get in touch with us to arrange a time for you, or a representative, to attend. See attached sheet for more information about complete Welding Services."

In a day or two, telephone calls and letters began pouring in, and as time went on, more and more interest was

"Red" McClure, Whose Welding Clinics Are Becoming Famous.

shown. The Wayne Welding representatives and "truck men" were asked about this new thing called "clinic" and what had to be done to get into it. The interest was spontaneous and came from every type of shop and industrial concern, large and small alike. Welders, foremen, engineers, superintendents, and factory managers came, and they aired, analyzed, discussed and worked out their individual problems for the common good.

The "clinic" has already had three meetings at the Wayne Welding plant, the attendance being upward of 100 at two meetings, and the other a few less due solely to below-zero temperatures, making it difficult for many to come from a distance. The subjects discussed were:

First meeting: Pipe welding. Aside from actual demonstrations, the Bastian-Blessing Co., Chicago, showed a moving picture of pipe-welding applications and procedure under a wide variety of conditions.

Second meeting: Cutting with the oxyacetylene torch—ways to effect economies, increase speed, improve cutting, various applications, etc. Two handsome prizes were awarded in the "cutting" contest, open to all who wanted to try.

Third meeting: The Air Reduction Sales Co., Chicago, developed the very interesting subject, "Gas versus Electric Welding," showing conclusively the merits of each in its own sphere of application. By the use of a very ingenious device, everybody could observe in minute detail the things to do and the things not to do in electric welding. Actual practical demonstrations were given.

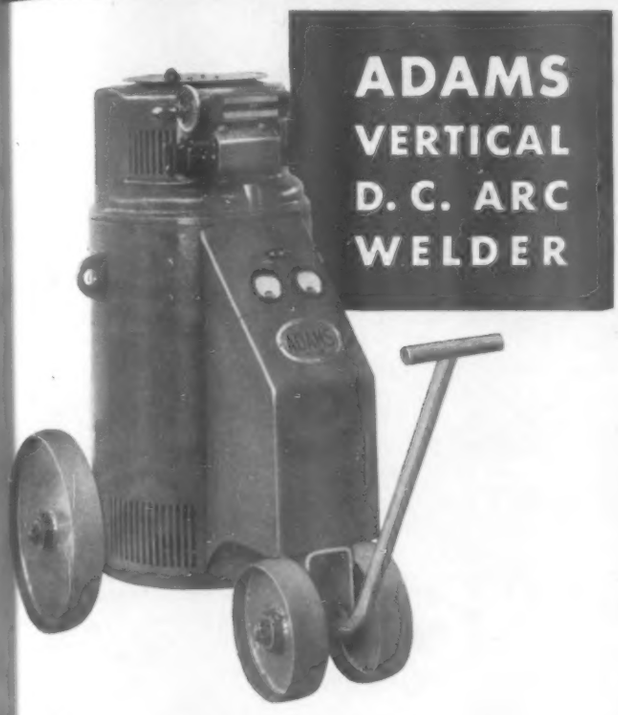
These "clinics" are to be made a permanent institution, meeting on the first Monday evening of each calendar month, says Mr. McClure, who believes that, in view of the support already shown, a great deal of good will accrue to that section of the country.

Bert Law Succumbs to Heart Attack

Bert N. Law, railroad sales manager of the central division of the Air Reduction Sales Co., with headquarters in Chicago, died in the early morning of Feb. 1st. His untimely death was the result of a heart attack suffered during the night. Members of his family tried to arouse him when they noticed that he was breathing heavily, but he never regained consciousness.

Mr. Law has been actively engaged in welding sales ever since he made a connection with the Searchlight Co. about 20 years ago. When the Air Reduction Sales Co. took over the Searchlight Co., Mr. Law became a salesman with the Aireo organization, and later was made Chicago district manager of the company, following which he was promoted to the position he held at his death.

In Mr. Law's death, the welding industry has lost a likeable personality and wise counsellor.



Offers These Advantages

In Vertical Design:

Gyratory Action which reduces vibration and commutator wear.

High Air Intake with horizontal discharge, which reduces pickup of metallic and abrasive particles destructive to windings.

Low Center of Gravity providing easy handling either on floor or by crane.

Requires Small Floor Space (30" x 42" for 400 Amp. Machines.)

In Electrical Design:

Interpole Stabilizing Windings which insure uniform current flow, hence uniform welding characteristics.

Dual Excitation from Commutator providing instantaneous arc recovery and snappy, smooth welding action.

Micrometer Current Control providing accurate current adjustment over unusually wide welding range.

Liberal Design of active iron and copper providing overload capacity without overheating.

Investigate this new outstanding Arc-Welder which is giving such complete satisfaction to users who demand highest quality and wide range service. Available in 200, 300, and 400 Amp. sizes NEMA ratings.

•

J. D. ADAMS COMPANY

Arc Welding Equipment and Electrodes

INDIANAPOLIS, INDIANA

No. 20 Helmet
Patent applied for

AND NOW—

Willson Welding Helmets and Handshields with Composition Glass Holders

Glass replacement is simple and quick in the new line of Willson Welding Helmets and Handshields with glass holders of a good grade plastic composition which will not warp or bend, does not conduct heat or electricity and is not affected by moisture or extreme temperatures.

No. 20, shown above with flip front in open position, permits instant weld inspection without raising helmet on the head. No. 330 does not have a flip front but in other respects is the same as No. 20. Both Helmets and No. 3 Handshield are made of strong, durable black fibre in improved design, with riveted construction; fitted with Willson-Weld glass protected by clear cover glass and can stand a lot of shop use and abuse.

No. 330 Helmet
Patent applied for

Three Position Headgear

The comfortable, adjustable headgear holds the helmet in three positions by use of a foursided drum which turns within a substantial straddle spring and holds each position positive. This headgear is standard in styles 20 and 330.

No. 3 Handshield has a strong, well shaped handle which affords a good grip and balance.

Prices, packed in individual cardboard cartons, f.o.b. shipping point.

No. 20 Helmet $9.90 each.

No. 330 Helmet $8.85 each.

No. 3 Handshield $6.50 each.

No. 3 Handshield
Patent applied for

WILLSON PRODUCTS, Inc.
Reading, Pa.

Motion Picture on New Multi-Flame Lindewelding

A new motion-picture film entitled, "The Multi-Flame Lindewelding Head," provides a graphic description of this comparatively new, rapid method of pipeline welding. This picture, which was filmed for the most part in the Midwest pipeline fields, shows the details of construction of this multi-flame head and the correct technique of manipulating the blowpipe and welding rod. Some unusual telephoto scenes illustrate the action of the welding and preheating flames and the proper control of the puddle.

This film is available only in the 16-mm. size. It can be obtained free of charge for showing to industrial groups, schools and similar gatherings, by writing The Linde Air Products Co., 30 East 42nd St., New York, N. Y.

Apologies are due C. M. Sauer for the misspelling of his name in the item in the January issue of *The Welding Engineer* announcing his connection with the Cincinnati office of the Air Reduction Sales Co. Also, the establishment that he one time operated in Bremen, Ind., was not a welding shop, as stated, but an electric shop.

The J. D. Adams Co., Indianapolis, Ind., has opened a sales office at 957 S. Lamar St., Dallas, Texas, in charge of B. B. Hunkapiller. The states of Texas and Oklahoma will be served, and all types and sizes of "Adams" electrodes will be kept in stock. This is the seventh district office to be established by the Adams company within the past twelve months.

R. A. Merritt, formerly salesman in the Chicago office of the Air Reduction Sales Co., has been promoted to the position of assistant sales manager of the company's Birmingham (Ala.) district office.

H. J. Howey, of the Sight Feed Generator Co., has moved his residence from Chicago to Richmond, Ind., in order to be more closely in touch with the general sales offices in that city.

· CLASSIFIED ADS ·

Help Wanted—75c per line, minimum 4 lines. Jobs Wanted—4 lines free. Other Ads—$1.00 per line, minimum 4 lines. Count 8 words to line. Add 6 words for keyed address.

FOR SALE

For Sale—200 and 300 ampere electric-drive and gasoline-engine-drive arc welders. We are welding specialists and furnish guaranteed arc welders and spot welders. Goodman Electric Machinery Co., 1060 Broad St., Newark, N. J.

Bargains—Demonstrator Arc Welders. Gasoline, electric drive, belted, or coupled-together outfits. 30 days' trial. Easy terms, if desired. Write Ken's Welding Exchange, Box U-251, Troy, Ohio.

Bargains—Electric-driven Lincolns, Wilsons and General Electrics, for sale or rent. Completely overhauled. Guaranteed. Service Co., 3741 Cedar Ave., Cleveland, Ohio.

EVER-KLEAR COVER LENS

Now in their fourth year of service, and are gaining new friends rapidly. They will not pit; this insures clear vision at all times. Guaranteed 200 welding hours.

Size 2x4¼ in. @ $2.40 per dozen
Size 45 to 50 M.M. @ 35 cents per pair

Dealers in Principal Cities

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Exclusive Distributor

Welding Qualification Tests
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in connection with

Building Construction
Pressure Vessels
Power Piping
Machinery Construction

WRITE FOR BULLETIN O-1 AND TELL US YOUR PROBLEMS

NATIONAL WELD TESTING BUREAU
a division of
PITTSBURGH TESTING LABORATORY
Pittsburgh, Pa.

AGENTS AND DISTRIBUTORS WANTED

READY SOON!
AGENTS WANTED

100-Amp. Arc Welder, driven by 4-cylinder air-cooled gas engine. First of its kind. Portable. Priced right. Write immediately for particulars. Address F-3, The Welding Engineer.

HELP WANTED

Engineer Wanted—With experience in the design and construction of D.C. welding generators, arc welding fixtures and arc welding devices. Address F-2, The Welding Engineer.

POSITIONS WANTED

Welder, Mechanic, Designer—Age 33. Desires connection with reliable party. Will make excellent proposition on patented, new type, light-weight, all-welded refrigerator body. Address F-1, The Welding Engineer.

Arc Welder—15 years' experience. Desires permanent connection with reliable concern. H. B. Furman, Box 466, Matamoras, Pa.

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WELDING ENGINEERING

For 32 years we have specialized in engineering training and now offer comprehensive PRACTICAL and THEORETICAL ARC WELDING courses under mutual working conditions. Nationally known engineers and technicians train you personally.

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No Puddling **WHITE METAL** No Flux

White Metal is easily and quickly welded with Aladdin Rod at a profit. Don't continue to lose profit by turning down White Metal parts. Only Aladdin Rod is guaranteed to produce welds of greater tensile strength than original metal. Unexcelled as an aluminum solder. Directions with each pound. If your jobber cannot supply you, order direct.

Assorted, 1/16 and 1/8 in., $2.50 per lb. 1/16 in. rod, $2.75 per lb.

THE ALADDIN ROD & FLUX MFG. CO., 947 Fifth Ave., Des Moines, Iowa